THE BASIS OF BREEDING

LEON F. WHITNEY

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THE
BASIS OF BREEDING

BY

LEON F. WHITNEY

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AUTHOR, A CHARITY TO LESSEN CHARITY AND OTHER ESSAYS.

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TO

HARRY HAMILTON LAUGHLIN

FOREWORD

THE subject of genetics is generally considered too deep for the layman. Indeed, it has been, as written and spoken in the past. When a layman comes upon the word, heterozygote, in a paragraph, the whole paragraph may be meaningless to him. For all he knows he may be reading about a farm animal. When such words as viviparity, spermatogenesis, phylogeny, monohybrid, epigenesis, brachydactylism, kayrokinesis, exogastrula, blastocoel, mesenchyme trophoblast, and so forth, rise up out of the printed page, he gives up hope and wonders why somebody "doesn't write all that out in plain English."

To be frank, the easiest part of writing this book has not been the conversion of such long words into plain English. Although the words are absent, their meaning still persists, I hope. So it will be a great satisfaction to me if I have made "The Basis of Breeding" not only readable but understandable to the average man.

What I have tried to do in this volume has been to give the necessary information which is fundamental to breeding. I have purposely omitted all such considerations as housing, feeding, exercising, bathing, surgery, etc. These environmental phases of breeding are to be found in a wide variety of books on domestic animals as well as veterinary books, hence the reader is referred to them for information on such phases. The material in the book is basic.

Without the assistance of certain of my friends I am frank to say that the book would not be nearly as complete as it is. Dr. George N. Papanicolaou helped me in my work on the mating cycle and made many suggestions for the improvement of the book after reading the section on the Physiology of Reproduction.

Professor Wesley R. Coe made available for my use scientific apparatus and gave me ideas and criticism of much value. Dr. Leslie C. Dunn read Part 1 and his criticisms were a real help. Dr. Harry H. Laughlin furnished the list of inheritable human traits and other data. Dr. Dewey G. Steele wrote the section on pigeon inheritance. Mr. Louis DeCasinova, Editor of the American Kennel Gazette, has made many excellent suggestions. Miss Lillian Armstrong has

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also given valuable assistance in many ways with both the manuscript and the proof.

Drs. Charles B. Davenport, H. S. Jennings, W. E. Castle, Edwin G. Conklin, Donald Jones, Helen D. King, Irving Fisher, William E. Hastings, E. G. Ritzman, and others have given suggestions or allowed the use of illustrations. The Journal of Heredity furnished the illustrations on pages 67 and 136. To each of the above, as well as to the various publishers and pure bred live stock associations, I wish to extend this formal but genuine word of thanks and to assure them of my deep appreciation.

My experiments to determine the Mendelian traits of dogs, and my efforts to determine the mating cycle necessitated the keeping of large numbers of dogs, all of which was financed by myself. In connection with the care of these dogs, I wish to thank Mr. William Reeves who assisted me with many of the unpleasant as well as the pleasant phases of this work.

Most of all I thank my wife who has given me the most hearty cooperation, and who has read and reread the manuscript and proof and greatly improved the book.

LEON F. WHITNEY

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PART I

THE HEREDITARY BASIS OF BREEDING

CHAPTER I

INTRODUCTION

HAVE you ever watched an animal and tried to pick it apart in your mind's eye? Have you ever tried to see more than the animal; that is, the factors of which it is composed? Suppose that you looked, and instead of seeing a dog, for instance, you saw a pair of erect ears, a short grey coat which seemed to stand up on end, a very thick coat, a tail that curled over the dog's back, four medium length legs; suppose you noticed that when the dog followed the track of an animal that he ran without baying, now wouldn't that be more interesting to you than simply seeing a dog? Of course it would.

The more individual traits which you could discover about the dog, the more interesting he would become. Where you had seen one thing of interest — a dog, you would now perhaps see twenty-five interesting factors. Or suppose you understood the physiology of the reproductive system and the underlying phenomena of birth, the facts about inbreeding, why like does not always beget like, would not all animals be vastly more interesting to you? Of course they would.

And if you understood the laws of breeding as they applied to heredity in the lower animals, don't you think it would be interesting to consider how these same laws applied to ourselves? If we know how to improve the breeds of domestic animals, why could we not just as well improve the future families of our own kind? We can.

It is imperative at the very beginning that we understand each other. I am not going out of my way to hurt the feelings of a single person. Neither am I purposely going to try to jar him by altering his pet theories. What I undo will be undone not so much by me as by science. I shall present facts about breeding, facts which I have gathered and discovered, facts which others have discovered, facts which apply to any animals, or plants, if they but shed light upon the subject of our interest.

Much of this material will have to be learned in place of old ideas, and that is a hard thing to do. It is a well established fact that is it harder to unlearn an old thing and learn a new, than it is to learn the correct thing in the first place.

It is far easier for a person to learn to typewrite correctly with no knowledge of the wrong method behind him, than it is for that person to unlearn the wrong and then learn the correct method. Business executives know that it costs more to train an experienced man in their methods which are new to him than it does to teach a new man. We breeders have learned so much misinformation that it is difficult to unlearn it all and learn the correct information in its place.

Each person is partial to some certain breed of animals. That is why I shall refer to breeds on a strictly utilitarian basis. I shall not say, "This breed is more beautiful," because people's ideas of beauty differ. Some people see beauty in an Ancon sheep or a pug dog. I do not, but that does not say I am right.

Some persons love the dispositions of certain breeds that I cannot seem to learn to like despite much experience which I have had with them. That does not mean that the dispositions are what I think them to be. I may have misjudged. In such matters I defer to the breeder's judgement.

I am willing to concede that much, and in return I shall expect a fair trade, namely, that the reader will offer no objection when I make such statements as these: the Percheron is built better for drawing heavy loads than the thoroughbred; the Holstein produces more milk than the Jersey; the Yorkshire is a superior bacon breed to the Poland China; the Airedale has less instinct for self-protection than the foxhound; the shepherd does not have equal scenting abilities with the bloodhound; the Cornish is naturally more pugnacious than the Couchin; the homer has more endurance than the common pigeon. These are facts based upon utility which have been demonstrated. It is therefore my pleasure to pass on to breeders of animals the information which I have derived from my studies, in the hope that it will make their lives even more enjoyable because it opens up new avenues of thought.

Since the facts of heredity are applicable to all kinds of animals including man, it is my hope that this book may do some part in making our own bodies and our own hereditary tendencies better understood to the end that we may help raise hereditary status of the human race.

A knowledge of the laws of heredity is of great *economic* value to any breeder. In view of the shortness of life, it behooves us all to understand them thoroughly. A man or

woman has but one opportunity to raise the hereditary standard of his or her family.

When a man or woman marries, he or she has chosen half of the ancestors of the children that are born from the union thus contracted. There is one momentous choice, and on that depends the quality of generations to come, provided that it does not result in family extinction.

If the wrong choice is made, the only hope is in the education of the children to think eugenically, and we must not forget that in this day and age the children prefer to make the actual selection of mates themselves, which is to be commended, providing they have had the proper education. One chance in a lifetime is the average person's allowance to improve the family stock.

Think how little the average man can actually do to improve the breed of animals which he fancies.

With cattle and horses there is an average of about five years between generations, counting the testing of the stock to determine its value for breeding. So the cattle and horse men have ten generations of cattle or horses on which to work to add their little improvement, providing they pursue their hobby or business from the time they are twenty-five until they are seventy-five. A man can not do very much in those generations. Life is too short, at best!

With most of the other animals a two year generation may be figured safely. Counting a year for maturity to be reached, and a part of a year each for testing, and gestation, the total is about two years. In that case a man has twenty-five generations in which to build up. Again, too short, too short! There is little time for mistakes. Surely it is worth patient study, in order that we may pursue our breeding work with the greatest possible efficiency.

No longer do we read by the light of flickering candles; so why not, once and for all, let us throw the tallow candle of tradition, predjudice, and superstition out of the window, and, just as we now read by the light of the incandescent lamp, so let us pursue our breeding in the light of modern knowledge.

There are large animals such as horses which claim the major portion of the time of certain readers of this book; there are others such as rabbits which claim the attention of a different group.

In so far as it is possible the animals used to illustrate points which we must know are of wide variety. But where general points must be illustrated the dog is often used, for many reasons, principal of which is that dogs are most plentiful of all animals which come under the observation of *everybody*. The dog also is an average size animal, sort of a common ground of understanding therefore.

If mice were used as an illustration the cattle breeder would lose interest, because mice are so far removed from the subject of his interest. If cattle were used the breeders of mice or pigeons would be disturbed because they have but little opportunity to observe cattle. If the breeders of all kinds of animals will keep these facts in mind they will see that dogs therefore furnish us with the very best illustration, understandable and known to all.

CHAPTER II

THE SCIENTIFIC ATTITUDE

THE difference between the scientist and the layman is largely one of training. The layman believes a good part of what he reads and hears. He accepts things without much questioning. He is a slave of precedent. But the scientist is a trained doubter. He doubts everything he sees in print until he knows it is an established fact. He demands proofs first of all. And these proofs must be genuine.

But the successful practical breeder needs to be more than a scientist. He must be both a scientist and a practical man. The scientist is interested in *knowing,* more than *doing.* Sir Michael Foster, in an address before the British Association said that there were three distinguishing qualities of the scientific worker:

"In the first place, above all other things, his nature must be one which vibrates in unison with that of which he is in search; the seeker after truth must himself be truthful, truthful with the truthfulness of nature; which is far more imperious, far more exacting than that which man sometimes calls truthfulness.

"In the second place he must be alert of mind. Nature is ever making signs to us, she is ever whispering to us the beginning of her secrets; the scientific man must be ever on the watch, ready at once to lay hold of nature's hint, however small, to listen to her whisper however low.

"In the third place, scientific inquiry though it be preeminently an intellectual effort, has need of the moral quality of courage—not so much the courage which helps a man to face a sudden difficulty as the courage of steadfast endurance."

In his little book, "An Introduction to Science," J. Arthur Thompson sets down what he thinks are the distinctive features of the scientific mood. He says:

"The scientific mood is especially marked by a *passion for facts,* by *cautiousness of statement,* by *clearness of vision,* and by a *sense of the inter-relatedness of things.* It is contrasted with the emotional or artistic mood, and with the practical mood, but the three form a trinity (of knowing, feeling and doing), which should be unified in every normal life."

These facts should be remembered by every breeder. If there is any one thing which has characterized breeders as a class, it is the snap judgments in place of facts, readiness to believe whatever appears in print, and dependence upon outgrown theories.

I doubt that any reader will review this book and not find several of his pet ideas upset. Anyone who has animals under his observation constantly, is bound to draw his own conclusions. I well remember that I had a bull whose head closely resembled that of a cow. He sired twenty calves, and nineteen out of the twenty were bull calves. Then I sold him to the butcher.

At the same time there was a stallion at the Massachusetts Agricultural College which was the most effeminate looking stallion that I have ever seen. And it seems that he sired a very high proportion of male colts. A ram also came to my attention which had been siring more than 75% ram lambs. He too had an effeminate look about his head.

Then I began to pick out men who had a certain soft look or expression, and it seemed to me that these men were the fathers of a very high percentage of boys. So I formed a theory, and as far as I could see it seemed to work. But the trouble was that I did not have enough cases to back up my theory. When I learned the cause of sex, this idea evaporated.

But it is no more foolish than many of the delusions held by the majority of people. The average man is looking for alibis instead of truth. It is our duty to forget our opinions in our studies and seek the truth.

As an instance of false beliefs which persists down to the present time let us consider the following:

The birthmark theory. Many people persist in believing it today. A pregnant woman ate some strawberries. They disagreed with her. Later her child was born with a strawberry birthmark. Or a pregnant woman was frightened by a mouse. Her child was born with a spot resembling a piece of mouse skin. Or a pregnant woman was beaten by her husband. Her child was born with a club foot. Such are the superstitions. (We shall see the reasons, later on, why they are not true.)

Not long ago a scientist doubted. He then found by scientific methods that there were more children with strawberry birthmarks born to mothers who had never even seen a straw-

berry during pregnacy than to mothers who had. One case after another of birthmarking he disproved until today no well informed person takes any stock in that antiquated idea.

Were we not taught in Sunday School about the great experiment of Jacob's in making his cattle distinct from his father-in-law's? Genesis, 30:37, "And Jacob took him rods of green poplar, and of the hazel and chestnut tree; and pilled white strakes in them, and made the white appear which was in the rods. 38, And he set the rods which he had pilled before the flocks in the gutters and in the watering troughs when the flocks came to drink. 39, And the flocks conceived before the rods and brought forth cattle ring-straked, speckled, and spotted."

Jacob thought that it was the rods which caused the speckling and spotting, when we now know that he might as well have spared his efforts; the spotting was caused simply by recessive traits appearing in the solid colored cattle which he used, and the rods which he pilled had nothing whatever to do with it.

The Bible is not unique in setting forth the record of this belief. It was perfectly natural that men should have sought a reason for this strange occurrence and birthmarking was the most natural to occur.

The whole theory got its start by people's willingness to believe without sufficient evidence. This is typical of the way much of the misinformation is circulated. A wise precaution for any breeder might be summarized in the following: *Never generalize from a specification; never specify from a generalization.*

Many unfortunate old women were burned as witches because our forefathers believed that they were possessed of the devil, and that by burning the witches they burned up devils too. This idea was only one manifestation of the idea that what we are is caused by something outside of ourselves, instead of by our hereditary makeup.

Even today we hear people say, "I don't know what possessed me to do that," or "I don't know what has gotten into me." The idea that the insane person is possessed of a devil still persists, despite the fact that scientists have proved that the only part the devil had to play in the case of a large proportion of insane persons was to tempt the poor victim's parents to marry.

Science has shown that we think as we do, we act as we do, largely because of the physical formation of the brain and the secretions of the body.

It was only four hundred and thirty odd years ago that everybody thought Columbus was going to sail to the end of the flat world and then drop off. Not long ago, the stars used to be lamps in the sky that were lighted when it got dark. The man used to be in the moon. Scientists doubted, and the earth became round, the lamps in the sky turned to suns and planets, many of which make ours puny by comparison, and the man in the moon became vast mountain ranges.

Recently the papers were headlined with an account of a heroic dog's rescue of a drowning boy. As far as the people on shore could tell, the dog had reasoned that if he did not fetch the boy to shore he would drown, so he did his duty. It was pure reasoning, and the dog was decorated with a medal.

But the crowd didn't know that the dog had been trained to fetch things to shore, and the next day a scientist saw the dog rescuing a stick which was floating in the river, with just the same fine show of heroism with which he rescued the boy. So he knew the dog rescued the boy from instinct and training, and not reason, despite the fact that there is so fine a line of demarcation between the two.

Fifty years ago many people believed that men and other animals had lived on this earth but four thousand years, but scientists now know that they have lived here at least a million.

So it goes, and so it shall be until a better race inhabits this planet—a race well educated and taught the folly of a superstition and belief without proof. But this need not deter us from being as open minded, as passionate for facts, as cautious in our statements, as clear in our vision, and as sensible of the inter-relatedness of things as any scientist. If we will but keep these requirements in mind, we shall find a new world of interest opening before our eyes.

And we ourselves can help to bring about that race by a thorough knowledge of the laws of heredity. These laws apply to ourselves as well as to our animals.

CHAPTER III

PAST AND FUTURE

It is safe to say that today no one knows the origin of all of our domestic animals. Take the dog family, for example. It is likely that they have descended from a wolf-like ancestor, the jackal, the dingo, or the wolf. Or perhaps all dog-like animals have arisen from a common ancestor.

Darwin thought that both man and the apes came from a common ancestor which has long been extinct. This may also

Fossil dogs, probably 3000 years old found in Indian caves in Arizona. Both had long hair and are mature, but of conspicuously different sizes. (From Peabody Museum, Harvard University)

be the case with the dog, and with other animals, as for instance the breeds of cattle, the horse family, sheep and goats.

Despite this lack of knowledge, we do know in what countries the principal breeds originated and we can see a striking interrelatedness between breeds with a comparatively

The horse had its origin in a small, dog-like animal. These skeletons, revealed by the record of the rocks, show its probable history. (From Tyler).

recent origin. The fact that all breeds within a species are fertile when crossed with each other, leads us to believe that they have all come from the same ancestor, no matter at how remote a time that ancestor may have lived.

It is interesting to speculate upon the manner in which the animals became domesticated. Dogs were probably the first. Possibly they were first used by man because of some service they could render him. There is a possibility also that they may have been only a curiosity which he domesticated as a child adopts a stray pup which strikes his fancy.

We find pictures of dogs with men in the most remote periods of which there is any trace of art. In many of these crude drawings or etchings on stone the dogs are pictured as helping in the hunt, killing a wild boar, chasing a buck, etc.

At the Museum of Natural History in New York there is a cabinet showing the evolution of the horse, starting with

the skeleton of the first known horse-like animal no larger than a fifty pound dog and ending with the bones of a one ton draft horse. It is fascinating to study this sequence of skeletons each of which was found in older strata thus indicating the remarkable change as the ages rolled by.

Does anyone believe there is no room for further change? I believe there will be great advances made. Surely the later advances shown in that group have been caused almost wholly by selections under the guidance of man.

Once docility was bred into the selected individuals, it was no doubt easy to accomplish domestication. Probably the method of changing the characteristics of a breed or a family of animals was by the selection of the desired type and using these animals as the breeding stock, more particularly a few desirable males which were used to sire the majority of the offspring. This is the common method of today and is known as the "pure sire" method. Almost all of the males of one generation are prevented from leaving offspring.

This is much the same as when one nation conquered another in olden times. The men of the conquered nation were kept as slaves and left no offspring; their women bore children by the conquerors. These slave children grew up and the boys went to work and, not being allowed to marry, left no offspring, while the girls became the mothers of children by the men of the conquering race. In each generation, therefore, one half of the characteristics of the conquered race were lost, until rapidly its children were almost pure children of the conquerors.

Today the animal which is most popular as a breeding animal is the one which has won the most ribbons in the ring or in the field. It seems, therefore, that with a few exceptions the judges of the breeds are the men who today shape the destiny of the breeds. They select the individuals which they consider the best. This does not make any difference whether they *are* best for their respective purposes or not.

A few men today are to be praised or blamed for the types of the breeds of tomorrow. The animals which they adjudge to be the best are those which will be selected as breeding stock, and these tend to stamp the future breeds with their imprints.

The breeders of the present are, for the most part, breeding in the dark. They simply breed to what has been adjudged the best. They wonder why some of their products are

inferior, why they do not have the desired color, why certain undesirable traits appear.

Undoubtedly all the breeds were selected and made what they are in this manner. But the selections had to be preceded by variations and sudden changes in the breeds themselves, and the crossing of individuals possessing these differences and the recombination of the traits. We shall learn about this later.

By selection (unconscious, perhaps), based on variation and sudden changes, therefore, man first developed docility in his beasts, in order that he might handle them. He inbred these until docile animals were the rule, not the exception. Then as man himself became more domesticated, he found increasingly numerous uses for his animals. For instance, he needed swift dogs to help him catch certain game, such as deer. He selected dogs with increasingly longer legs and slender bodies for speed. He wanted others for hunting the wild boar. He selected those with characteristics which made them useful to him, and to themselves, for their pursuit. He wanted a dog which would go into the burrow of a badger and fight to the death. He developed by selection the short legged breeds with their indomitable courage. He wanted sporting hounds to drive the game, and bay so that he could hear by their baying in what direction they were going. He took advantage of a nervous trait which made the dog bark when he smelled the animal's track. Thus he developed the breeds of hounds. And in fairly recent times, he took advantage of the pause before attack and selected for that until he had lengthened it and thus developed the bird dogs. He wanted a little creature to please the fancy of some pampered queen, perhaps, and he selected for dwarfness, until he had created a tiny lap dog.

He wanted horses which could outrun those of his neighbors, and he bred for leg length, great heart, deep narrow body build; or draft horses which could draw heavy loads, and he bred for weight, short legs, and a round barrel.

He wanted cattle which would produce milk or meat or both, and the experience his ancestors had left to him in folklore told him to breed for certain physical characteristics which were conducive to these qualities.

He wanted a pigeon which could return home rapidly from great distances, so by a terribly ruthless elimination of those

lacking in this ability he weeded out the unfit and selected the fit until now his home-comers are the rule at long distances where once they were the exception at ten miles.

Thus, no doubt, were the breeds of animals and birds originated. And while in some cases it has brought about the development of many birds and beasts extremely useful to mankind, we must also admit that the selection has caused

How different from its ancestor, is this tiny lap dog, the Chihuahua, helpless under natural conditions.

the development of some which, like the high testing dairy cattle, the hairless or the Pekingese dogs, and the fan tail pigeon, would be utterly helpless under natural conditions.

CHAPTER IV

WHAT DOES BLOOD TELL?

Now that we are acquainted, let us start right out by upsetting the greatest fallacy regarding breeding that persists in the world today, namely, the blood theory.

Seventy-five years ago James Russell Lowell ended his great poem, The Present Crisis, thus:

"Nor attempt the future's portal with the past's blood-rusted key!"

BLOOD-RUSTED KEY! Up until now, the key to heredity has been blood. That key is now so old and obsolete that it is rusted, so let's forget it after we know why we should.

Not long ago I heard a speaker orating from the platform. He said that there was one thing of which he was proud above all else, namely, that the blood of William the Conqueror was coursing through his veins.

That is a beautiful piece of flowery rhetoric which scarcely ever fails to thrill an audience. But I was seized with a desire to shout "rubbish." And this was the reason: in the first place that speaker did not have even a drop of the same blood with which he was born, in his veins. Therefore he had none of his mother's or father's blood in his veins, and naturally he had none of William the Conqueror's.

This seems like drawing a sharp distinction. Humanity has been in the past in the habit of talking about blue blooded, pure blooded, animals and people, when they wished to explain the purity of breeding. The orator took pride in his possession of the blood of William the Conqueror, the horseman brags about his racer having the blood of George Wilkes in his veins. The dog man traces his dog's blood back to some famous sire. And it was quite reasonable that they should. Before the days when we knew much about the science of breeding this blood theory certainly seemed logical.

Some doctors, years ago, dissected a man and found that there were a number of tubes running through him which were hollow. They could not understand why these hollow tubes were to be found going to every part of the body. They assumed that they carried the supply of air and so they called them arteries, meaning air tubes.

And they found more tubes that were full of blood so they called these veins. As far as they knew, the blood went coursing through these veins. They could understand how it got there, because the heart pumped it, but they did not know how it got back. So the veins were the important thing and they are to most people today. But those arteries we now know are the tubes which carry the blood away from the heart and the veins carry it back. The arteries are empty after death.

Even Charles Darwin had the "blood" idea of heredity. When he tried to account for the method of inheritance, he had a notion that each organ sent little imaginary things, which he called gemmules which handed forward the inheritance. These, of course, were supposed to be floated around by the blood stream.

If it were not that this mistaken understanding of the very basis of breeding were so absolutely foreign to the actual facts, we would not have to dwell upon it to eradicate the notion from our minds. But almost everyone has the idea that blood is somehow mixed up with breeding and the mechanics of breeding.

One of the best known dog fanciers in America told me recently that he had a dog which was partly from one father and partly from another, because both of these dogs had been mated to the same female, and their blood had mixed.

Blood, in the past, was the only plausible explanation of the mechanics of breeding. At about the time for mating, certain female animals discharge some blood from the reproductive organs. When mating took place, it was commonly thought that the male discharged some blood into the female's reproductive organs, the blood of the two mixed and the offspring developed.

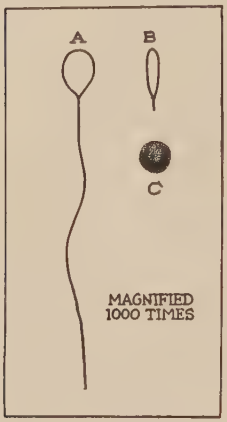
In fact, almost all persons believe today that the bloody discharge is the warning and that if mating takes place about that time, that pregnancy will follow. We shall deal with this fallacy in the chapter on the mating cycle (usually called by scientists, oestrus cycle).

Now, as a matter of fact all animals have a *bloodless* beginning. It is some little time after fertilization takes place that embryonic animals acquire blood, and then the blood they do acquire is that which their own organs manufacture. Even the blood of the mother does not reach the developing young

(foetus) within her. Her blood is separated from the blood of the young by a distinct membrane. It simply feeds the young, which manufactures its own from her food.

All animals start as a single cell. That cell is the product of a large cell which is furnished by the mother and a much smaller cell which is furnished by the father. These incomplete cells merge and form one complete cell.

As I look through my microscope at the tiny cells which the male dog contributes—those little tadpole-like cells—and realize that I am seeing them five hundred times as large as they really are, I cannot but think how wonderful nature is.



A and B—top and side view of a sperm. C—the type of cell that furnishes red color to the blood. Contrasting C with B it becomes apparent that we do not inherit blood.

And as I see one of the little particles which make the blood red (red blood corpuscles) along side of them, I cannot but smile when I realize how foolish was the old theory that "we have our ancestors' blood in our veins."

Here, for example, is a description taken from a Canadian dog magazine of how a fancier originated the bull mastiff, a new breed of dogs. Perhaps he understood that blood had nothing to do with genetics but what do *you* think? Doesn't it imply the idea of dilution? Notice how he refers to percentages.

Had he understood genetics he would have known that his desired traits were either there or not there and his procedure would have been very different. He would not be trying to "mix blood," but to select for traits:

"To produce a dog I had in mind, I set out with a well-defined plan. Having planned my work I worked my plan for my first pillar on the following foundation.

"Taking a mastiff bitch and a bulldog, I produce a 50-50. A bitch of these I mate to a mastiff dog, and this gives me a 75% Mastiff — 25% Bull bitch, which I mate to a 50-50 dog. A bitch from this litter, 62½ Mastiff, 37½ Bull, I mate to a 50-50 dog, and a bitch from this litter I put to a 62½ Mastiff — 37½ Bulldog, which gave me approximately my ideal 60% Mastiff — 40% Bull.

"I repeat this from other blood lines as an outcross, and thus I establish my strain, and the Bull-Mastiff, a standard breed of set type, which breeds true — like produces like."

This is not meant to be a criticism of the gentleman; he happened to accomplish his desired result but not in the most efficient manner. From his account one would not think he ever selected but that all of the pups had been uniform. As a matter of fact, he bred genetically and selected as well, but he explained his results on the basis of dilutions as if he were mixing water and ink. It illustrates the present viewpoint of almost all animal breeders.

We have all read about scientists taking blood tests to determine the paternity of a child. But when we read that, we must remember that what the scientists are actually testing is not whether the child received any of its blood from its parents, but whether the child is able to manufacture blood just like certain persons who are supposed to be its parents.

It is the blood-making equipment in which the scientists are interested, for that is one of the results of the development of the cells which first went to make the child.

I know of a mother who very nearly bled to death as the result of an accident. Her husband was away, so blood was bought. A transfusion saved her life. The man who gave the blood was a laborer who had never risen above digging ditches and selling his blood at twenty-five dollars per pint. Subsequent to the transfusion this fine woman has given birth to three children.

If her blood had anything to do with the heredity of the children, we could not expect much from them in later life. But already one of them, now thirteen years old, has a better mental equipment than the ditch digger who gave the blood. The fact is that the blood of that man was entirely lost to

that mother within a short time. No, blood has little else to do with the process of heredity, aside from the nutrition it furnishes.

So having dispensed with the idea of blooded heredity, let us dispense with another idea which our orator friend brings to mind by his mentioning the name of William the Conqueror. First let us see that if blood were passed on, which it isn't, how little of William's blood the orator would have had in his veins.

One generation back he had two ancestors, his mother and father. Two generations back, he had four, his grandparents. Four generations back he had sixteen. It was thirty-four generations back to William. Figure it out if you like. You will find that in 1066, the generation of William, the orator had over 17,000,000,000 ancestors—yes, in that one generation alone. So one seventeen billionth of his blood would have been William's except when inbreeding made it more concentrated.

Now can anyone tell me how William was any more important to our orator than any one of the other seventeen billion ancestors? Of course not. There might have been one hundred feebleminded persons in his ancestry, which would make them one hundred times as important as William to him, but he had forgotten all about *them.*

We are just as foolish as that with our horses, cattle, dogs, poultry, and so fourth. We single out an ancestor, perhaps ten or fifteen generations back, and brag about him in our animal's pedigrees. What we should be interested in is three or four generations back, and *every single individual in that generation and since.*

We shall learn later that some traits drop out of the heredity of animals and are lost to the progeny forever. It therefore behooves us to forget blood and our efforts to trace to distant ancestors and to give our attention to the real basis of heredity—the cell, that insignificant creator of us all.

As a preliminary consideration let us realize that the bodies of most living organisms are only an accumulation of an innumerable quantity of tiny units called cells. With the naked eye we cannot realize that fact because these units are smaller than the eye can see, but with a microscope we can see them, study their methods of growth, and fully appreciate that a man or a dog is in reality an enormous organism.

Size is a matter of comparison. When we look at the stars and know how small our earth is by comparison to some of them, or when we are in the great open spaces and look at a mountain we feel that we are insignificant specks moving about in this great world. But if we compare ourselves with some of the one-celled animals or plants, we see that we are positively huge entities, and our chests can fill with pride when we recognize our relative size and importance.

One of the smallest animals is the one-celled organism called amoeba, which lives in stagnant water in ordinary country roadside ditches. A handful of ditch water in summer will have from one to a thousand or more. It does not crawl or walk, it simply flows along by protruding part of its cell wall and flowing into the protruded part and then drawing the rest of its cell wall up to it. It is a typical one-celled animal of which there are many in varying forms.

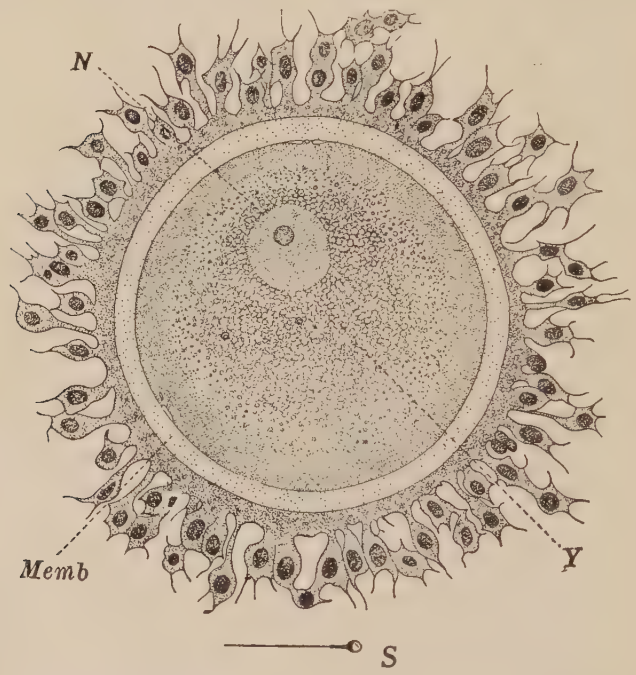
The bacteria are also single celled organisms. They, too, are of all sorts and forms from straight lines to corkscrews, and of all sizes. Some are so small that they have never been seen or caught, while others are visible to the eye as tiny specks.

Then there are other organisms consisting of small groups of cells and so on through the known forms up to man, in whom the cells have become intensely specialized. There is a great inter-relatedness between all the higher forms of animal life—so much so that they are extremely similar. Therefore, when we understand the underlying principles for one form of animal, we understand them for all.

CHAPTER V

THE GERM CELLS AND THEIR DESCENDANTS

I have said that the origin of all animals is a single cell, formed by a cell which the father contributed and another larger cell which the mother contributed. Let us start with



A mature female germ cell (ovum) and (S) a male cell (sperm). N—nuceus. Memb.—membrane. Y—yolk. (From Waldeyer.)

this first fertilized cell, and from it we shall trace the development of the animal. Let us study the cell and learn what it is, how it develops, what constitutes its construction and other matters of interest concerning it.

In order to fully appreciate the minuteness of this cell, we must remember that it is so small that it is not visible to the naked eye, except rather as the smallest dot imaginable.

The sperm is much smaller than the ovum, there being about as much difference as is shown in the illustration. Indeed the sperm is so tiny that if it were possible to assemble as many of them as there are men, women and children in the world, they could all be held in the cupped hands with no danger of overflowing. Seventeen hundred million is an enormous quantity, but the cells are exceedingly small.

The first time we become acquainted with the egg cell, (ovum), we find it in the tubes leading from the ovary of the mother. This female part has just been discharged from a blister-like growth on the ovary. A male cell or sperm which was one of thousands waiting near the ovary or in the tubes for the female cell to be discharged, has moved up to the female cell, shed its tail-like arrangement and gotten under the covering of the female cell. It has fused with the female cell.

This cell is now an animal. Within it are all the constituents, all the complicated paraphernalia, all the architectural plans for producing an animal.

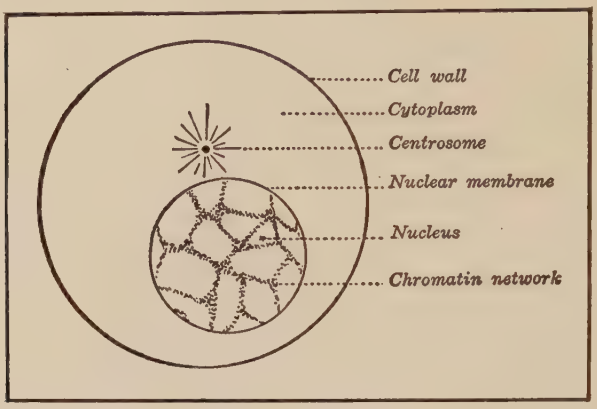
It asks only two things for its development — food and shelter. It does not even ask for clothing. It asks first for a few weeks or months residence in a protected spot within the mother. Then it asks the protection of the mother for another short period while it is more or less helpless or blind. Then it must have her protection for several weeks or months more before it is ready to shift for itself.

I have reference here to the natural kind of animal—one patterned as nature meant it to be, to fill the requirements of certain surroundings. If our animal is a high test dairy cow or a lap dog, or one which has been developed by man's fancy to be far removed from nature's plans, then it will need the care of man all through life.

For food during its first period of life, it asks that its fleshy shell or envelope may lie next to the lining of its mother's nest for it, so that the mother's blood may flow through that nest, produce nourishment, which its own fleshy shell may absorb, and thus grow.

So far as we could see with the best microscopes available, we would find that our cell looked like the diagram. Of course if we were to move the cell from its nesting place, we would destroy it. Our information is derived from hundreds of other cells which have already been destroyed.

The cell is surrounded by a wall which is very delicate and thin. Within the wall is a substance called the body substance (cytoplasm). Within this body substance, there is a little



A typical cell. (From Walter)

globe-shaped body called the nucleus. When the cell is in a resting stage, as the one in our diagram, there appears to be a network all through the nucleus. Very near the nucleus is a tiny body which is called the center-body (centrosome).

That is all there seems to be to it and yet this tiny bit of jelly will some day perhaps produce an animal which will be over 2000 pounds in weight. Let us see how it grows so large. Let us watch the process step by step at least until birth.

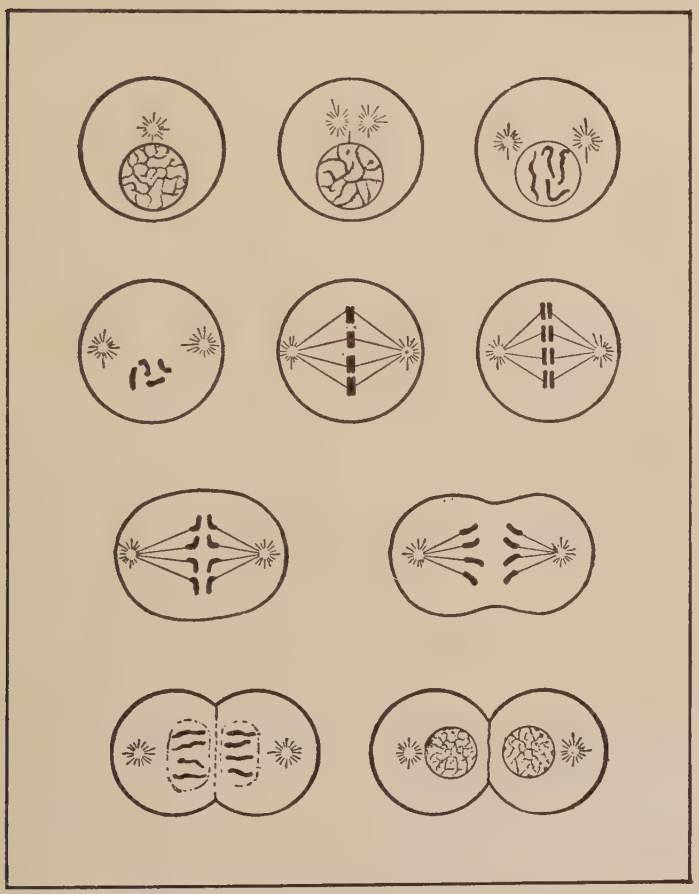
The cell rests for a few minutes or perhaps hours after it is fertilized. Then it becomes two cells. Scientists call cell division, mitosis. Look at the diagram and there is a moving picture of one cell becoming two, in a diagramatic form. It looks simple, but here is what happens:

First the centrosomes move around to opposite sides of the nucleus. They appear to work like magnets and under the microscope there appear to be very delicate threads running in toward the nucleus.

The network which we see within the nucleus now appears to change. Let us pay particular attention to that network. It is believed to be nothing but innumerable little packets of chemicals floating about in a pattern which looks to us like a

network. The network gradually becomes a lot of distinct lines, leaving no network to be seen. It is believed that the little packets congregate so closely that they appear to be lines.

This is the most important thing to know about in this whole subject of breeding. The reason is this: the tiny pack-



What happens when cells divide (From Walter)

ets of chemicals which we have seen congregate into lines are the *carriers of the heritage.* Nobody knows how many there are in the cells of any animal. In one tiny fly, the fruit fly,

which can be seen in such swarms about garbage pails in the summer, Dr. Morgan and his associates of Columbia University have found over two hundred. He has worked it out so carefully that he knows just where each of these lie on the different lines. But his fruit flies have only four of these lines or bodies.

The lines of the tiny packets are called color-bodies. The reason for this is that before we can see much of the cells and study them, they must be stained, and the parts of the nucleus which take up the stain and become visible are called color bodies or *chromosomes*. This scientific term has become so commonplace today that it is well for us to use it hereafter in this discussion.

Also we must learn the names for the little packets of chemicals,—genes. They are called factors, and determiners, but we may as well use the more terse term. For a long time it was believed that each one of these genes was the representative of one characteristic of the body. There was supposed to be one for hair color, one for eye color, and so forth. Today it seems a proven fact that it is groups of these genes which work together to produce the different characteristics, and that the absence of one from the group or the difference of two finally determines the trait.

But in the end it amounts to the same thing in our consideration. The odd one which determines the difference in the trait is the one which will interest us. So we can avoid needless confusion by regarding each of the genes as the factor which determines the trait that we are considering.

After the centrosomes are at opposite sides of the nucleus and the lines or chromosomes have become distinct, then they proceed to split in half. Each half gets the same number of chromosomes as the original cell had. Therefore each gene must have divided and become two.

Then the chromosomes draw apart toward the centrosomes and a wall begins to form about them. The wall of the cell begins to sink in and a division takes place making two complete cells, where only one had existed before. The chromosomes then become a network again and we have two cells each exactly like the other.

These two cells must now both multiply into two and then we have four. The four become eight, the eight become sixteen, the sixteen become thirty-two, and so forth. Right

here it is interesting to note that the reason an animal appears to grow so much faster as he gets older is easily illustrated by the fact that his cells divide at certain intervals.

Let us suppose that it takes the first cell one hour to become two. Then if we think of the embryo at the 1024 cell stage, we will see that it takes it but another hour to become twice as large. During its first hour it had doubled in size but its gain in size was to tiny as to be scarcely appreciable.

If in the same time it had 1024 cells all of which double, it would have an increase in size of 1024 cells. That would be very noticeable. Of course the embryo does not continue doubling its numbers of cells with such regularity.

All along the line in its development certain cells stop. The brain cells are supposed to become fixed and to remain the same all through life.

Other cells continue to grow all through life. The nails never stop growing, likewise the hair, the teeth, the cells of certain internal organs. Some grow very slowly, others very rapidly. The mammary glands, for instance, in the nursing mother manufacture cells exceedingly rapidly. As the young animal sucks the teat, the cells in the mammary glands break down and give up the product which they have manufactured, namely, milk.

However, we can see why the embryo grows more rapidly as it develops. In the human, for example, by the end of its first month, it may be little larger than a wheat kernel. At the end of the second it is about the size of a large pea. At the time of the third, it is as large as a walnut. It took just the same length of time to grow from the size of a single cell to the size of a wheat kernel, as it took to grow from the size of a pea to the size of a walnut, because there were more cells to divide.

The cells are so tiny and yet the grown animal is relatively so immense that it is easily seen that there must be millions of cells needed to produce it. Dr. Donaldson has estimated that there are 1,200,000,000 nerve cells in the human brain. The total number of blood cells in the human body is supposed to be in excess of 26,500,000,000,000. So the original cell which was made by the joining of the sperm with the ovum had a good many divisions before it was complete.

Such a figure staggers the imagination. We feel that we are enormous entities by comparison, and when we think of the insignificance of the original cells from which we and all

animals have sprung, it gives us a deeper sense of the value of this most valuable of all materials, the germ plasm, this link between generations, this Ark of the Covenant.

TWINS — IDENTICAL AND ORDINARY

Now that we are considering the cells, we must understand the cause of twins. In a sense, any two animals in the same litter might be said to be twins. They are the most common sort. But there is an entirely different kind of twins, known as identical twins. And this is how they are produced.

We saw that the first cell divided and became two, that the two divided and became four, and so forth. But if by any chance the first cell divides and the two become separated, instead of staying closely together, then we would have two separate individuals developing from the two cells. Each of these would be like the other so far as heredity goes. They are so extremely similar that even their fingerprints are practically identical. They are to all intents and purposes the same individual.

With human identical twins there are several instances of both becoming sick with the same disease within a few days of each other, even though they lived apart. If one becomes insane the other frequently does, even though thousands of miles may separate them physically.

Identical twins have taught us some of the most wonderful things we know about heredity and the effects of environment. They show that the environment makes less difference than was formerly believed and that the grown man or other animal turns out to be practically what his first cell determined he should be.

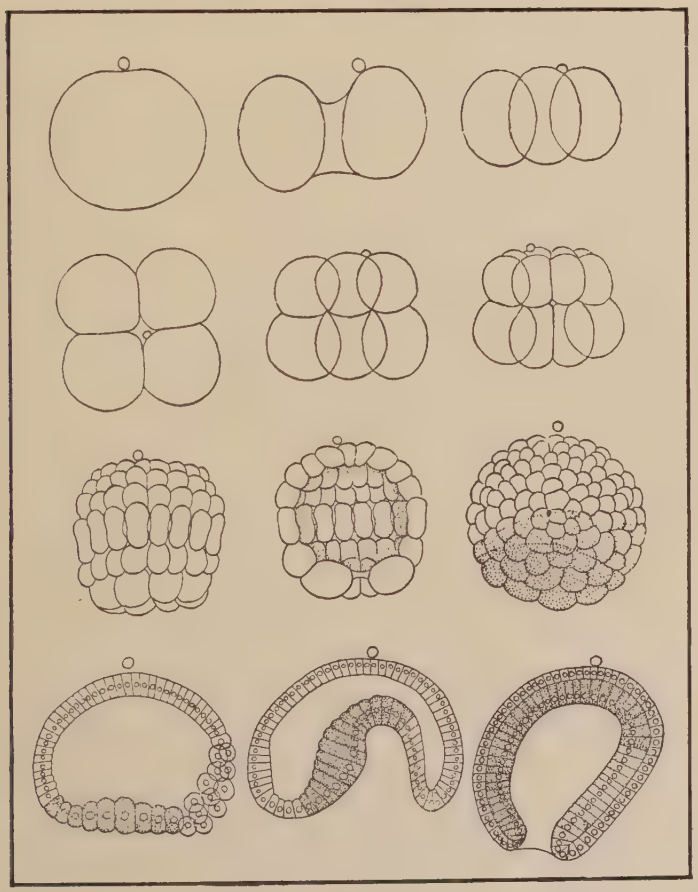
If a dog's first cell determined that he should be a pointer, he will be a pointer and nothing else. The amount of training may determine how good a pointer he shall be, but his heredity has, nevertheless, a great deal to do with that. However, we shall consider the effects of environment under the chapter on the inheritance of acquired characteristics.

It will be very interesting if breeders will look for identical twins among their live stock and report them in their magazines, making certain that they are not simply animals which bear a close resemblance to each other. If they are identical, they will not only look alike, but they will be so much alike that to all intents they will be the same individual in two parts.

A pair of indentical dog twins would make a great subject for a study of canine intelligence and animal psychologists ought to be eager to obtain them. Also if they were of a hunting breed, they would make a wonderful team.

DEVELOPMENT OF THE EMBRYO

As the group of cells grows, it takes the form of a hollow globe like a tennis ball. This globe gradually changes its shape. A crease appears along one side of the globe and the crease becomes deeper and deeper until it has sunk in to the



The first stages of growth in any animal. (From Conklin)

other side of the globe. Then the edges grow together until half of the globe is now inside of it and half out. The outside becomes the exterior of the animal and the inside becomes the interior. On the sides some buds begin to grow, which finally become the legs.

One very curious thing about the growing foetus, as it is called, is the tail. All animals have a tail during their development. The partly developed human foetus or embryo has a very definite tail, which gradually shrinks as the embryo grows. In fact, at one stage in the development it is very difficult to differentiate between a dog, a human being, a tiger, a cow, or a pig.

Frequently we see experienced breeders of animals feel of the skin of an animal to determine its quality. We hear it said that "quality goes clear through." It does, and the reason is simple, and has already been explained. The interior is only a continuation of the exterior and the line down the center of any animal is only the place where the sides of the globe came together and united.

THE GERM PLASM

It is thought that at the sixth division of our original cell is the time when a certain lot of cells are set apart to be the germplasm. If it is not at the sixth, it is very near the beginning of the development. And it is extremely interesting that this should be so.

The germplasm is not manufactured by the individual. It manufactures him. The animal received his heritage from his parents. So do we. That heritage is stored away within him until the time when it may be handed along to the next generation. As the embryo develops, this germplasm which is set apart becomes a part of the testicles in the male and a part of the ovaries in the female.

THE GENES AND CHROMOSOMES

Let us first consider the genes and chromosomes and then study into the male and female germ cells.

As the stage of developement when we can see the chromosomes distinctly with a microscope, the following are the numbers to be found in the germ cells of various animals.

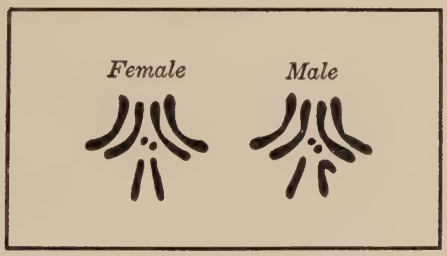
ANIMALS

Earthworm	32	Salamander	24
Leech	16	Frog	26
Snail	24 and 48	Pigeon	16
Water Flea	4	Oppossum	22
Cray Fish	200	Hedgehog	48
Cockroach	34	Armadillo	60
Cabbage Butterfly	30	Rabbit	48
Gypsy Moth	62	Horse	60
Mosquito	6	Monkey	48
Fruit Fly	8	Man	48
House Fly	12		

PLANTS

Yew Tree	16	Currant	16
Pine Tree	24	Tomato	24
Fir Tree	32		
Pea	14	Corn	20

No microscope has yet been made which would enlarge the chromosomes sufficiently to enable the scientist to see them clearly enough to know just how the genes are held in their proper order, but it is known that the arrangement of them makes a great deal of difference in the finished product. The

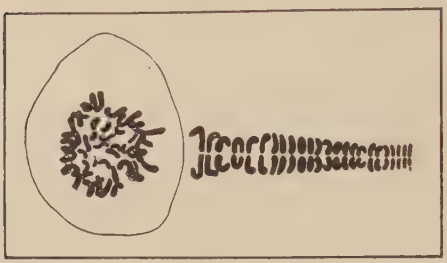


Chromosomes of the fruit fly. (From Morgan)

change in the arrangement of only a few will make a considerable difference to the fruit fly. And as the genes are so tiny that no one can tell to look at them which gene or which group of genes has the control of which trait of the body, we cannot say with certainty just how they work to produce their results.

In appearance the chromosomes have various shapes. There are some which look almost like globes. There are others like rods, and others like bows or hairpins. Some are thick and some thin.

But one of the most important things to remember is that they are always in pairs except in the female cell when it is just about to be fertilized, and in the male cell when it is in



Chromosomes of a negro. (From Painter)

a condition or approaching a condition to fertilize the female. At all other times the chromosomes are in pairs. We have said that in the human there are forty-eight, or twenty-four pairs. Each one knows its proper partner.

It is highly important that we keep the chromosome and gene theory clearly in mind in all of our breeding work. It underlies much of the best of our study of breeding and it is the foundation for all. Hence it would be well for the reader to review this section and to have it clearly in mind before he proceeds further.

Let us investigate the female cells, the male cells, and see what happens when the two unite, for there is fully as complicated a process required for this as there is when the cells divide, and incidentally we shall learn of the cause of sex.

CHAPTER VI

THE CAUSE OF SEX

We have already referred to the cells being set apart at the sixth division stage. Let us first look at the female cells, assuming that the animal is now mature and that the cells have grown to become the required number within the ovary.

THE FEMALE GERM CELLS (OVA)

Within the ovaries there are many thousands of resting germ cells, all of which constitute the germ-plasm. At a certain time, of which we shall learn more when we study the mating cycle, a few of these cells ripen.

All of these are the lineal descendants of the first cells and there they lie waiting for their turn to do their part. When the turn comes the cells first divide several times into one large cell and one very small one.

The large one is the one which will become the egg or ovum. The small one seems to contain only a nucleus and very little else, and is cast off as useless. The large cell divides again only emitting the small nucleus.

Just before it is fertilized it undergoes another division of a different sort. This time half of the chromosomes are discharged and half retained. Now notice this carefully as it has a great bearing on breeding. Some of the genes in the chromosomes which were thrown away may have been genes which were determiners for certain traits and the remaining ones might produce a very different trait.

Suppose that one of the genes had been a determiner for a white color, and its mate had been the determiner for a black, and the black had been cast off with the rest. Then that black would be lost forever from the germ-plasm of the offspring which this cell might make.

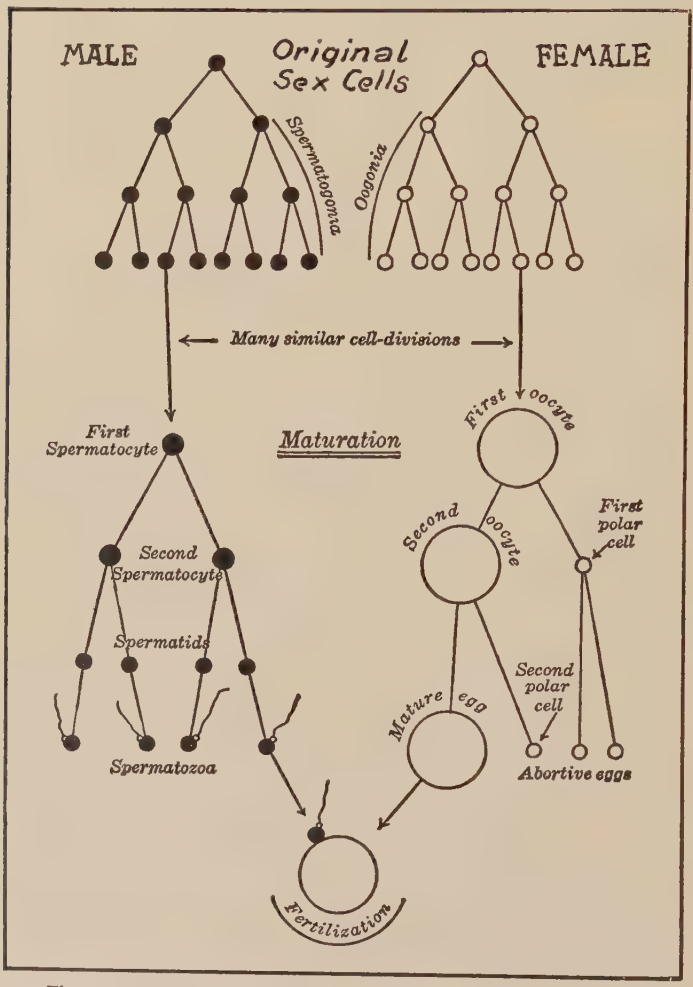
If we looked carefully at the chromosomes we would find that *all* of them in the female were like their partners. In the male we will find that in one pair there is a difference.

THE MALE GERM CELLS (SPERM)

In the testicles of the male lie the germ cells which are the descendants of the original cell, containing duplicates of its genes so far as we know. In the testicle, however, these are

continually dividing, half remaining to divide again and produce more and half dividing to produce other cells. This one which does not remain is called the sperm body (spermatocyte).

It divides, half of the chromosomes going to one and half to the other—that is, half of each chromosome (or 48 in the



The manner in which the original sex cells become sperm and ova. (From Walter)

human) to each. These, however, divide again and at this division one set of the chromosomes, 24, goes to one and one set to the other.

And then a tail-like attachment grows on the tiny cell and at the proper time the sperm may be discharged into the female to fertilize the ova. The sperm are very tiny, 1/2500 of an inch in diameter.

So we see that the ovum and the sperm have each received 24 chromosomes and not 48. Therefore when they unite they will each bring half of the heritage. So when someone says that when a man marries he is choosing half of his children's relations, it is correct.

And it is likewise correct to say that when we breed our animals we are choosing both halves of the relatives of their offspring. An animal receives equally his heritage from his father and his mother, or their ancestors.

THE DETERMINER OF SEX

We have seen that all the pairs of the female's chromosomes are alike. But the male is different in this respect. His chromosomes are all alike except one pair and they are quite different in appearance. We have seen how in the last division, half of the chromosomes go to make one male germ cell (sperm), and half go to make the other. Let us call one of the pair of differing chromosomes, X and the other Y. Now when they divide it is certain that X must go into one sperm cell and Y into the other. Therefore half the sperm cells will have X and half Y.

But in the female cells, the pair that correspond to this X Y pair in the male cells are not unlike. They are both X. Therefore all of the female ova will have the X chromosome very surely.

Now let us see what is going to happen. Suppose we have eight ova all ready to be fertilized by the sperm. Every ovum will have an X chromosome. Here are a whole army of several hundred thousand sperm to fertilize the ova. Half of the sperm have the X chromosome and half the Y.

Suppose that one of the sperm with an X chromosome is the lucky one to unite with an ovum, what happens? Easy. They will pair off their chromosomes and since there will be 2 X chromosomes, one from each parent, the offspring will be

a female. But suppose a sperm with the Y chromosome arrives first. Then there will be one X and one Y and the offspring will be a male.

Recent discoveries seem to show that with the lower forms of life there may be something deeper than the chromosome theory of sex; some other factors seem to influence it too, possibly by altering the proportions of the X and Y chromosomes. Perhaps the future will reveal the deeper cause.

Dr. Oscar Riddle of the Carnegie Institution reports a dove which because of tuberculosis of the ovaries, developed a pair of testes and apparently turned into a male, even fertilizing his mate's eggs which hatched. He also reports a hen which did the same. This would of course not be possible with mammals on account of the physical construction of the reproductive organs. The X and Y chromosomes, however, explain the ultimate reason for the difference in male and female.

Now that is the explanation of the cause of sex. It doesn't tally very well, for instance, with the theory of the man who says that in order to have *female* young you must mate your animals on the last day of their mating cycle. Neither does it tally with the theory of the man who says that to have *male* young you must mate on the last day. There isn't any way to make sex to order and it is very probable that there never will be. The germ cells are too small for us to tinker with.

Sex is only a matter of chance. The chances are that four out of eight ova will be fertilized by X-bearing sperm the other four by Y-bearing. Of course is is possible that the only sperm to fertilize the ova might be X-bearing. In fact, the chances are the same as flipping a coin. Suppose we sat down when we had nothing to do and flipped a nickle 200,000 times. Very frequently we would have a run of eight heads and the same for eight tails. But in the long run we would find, if we kept count, that we had 100,000 heads to our credit and 100,000 tails. That is almost what we may expect in sex determination.

Whether or not there is any selection of sperm by the ova we do not know, but there is a possibility that there is some small selection. I believe that it is settled fairly well scientifically that the X and Y chromosomes are the determiners of sex. I am not so sure that the ova have any power to select an X-bearing or a Y-bearing sperm under certain conditions or not.

The reason that it is necessary to mention this is because the census shows that there are 106 boys born for every 100 girls in our population. Dr. Helen Dean King finds from her records of thousands of rats that the same proportion prevails.

I have recently received from Germany a tabulation of the litters of German shepherd dogs born and find that of 7,462 litters totaling almost 50,000 individuals, that there were 25,559 males and 24,091 females. Reduced to percentages, this is equivalent to 106 males born for every 100 females, or the same proportions as the human family.

There is also another explanation which might apply to this case; namely, that the males may be more vigorous than the females and fewer die in the uterus. This might apply to animals which have litters of young but it would not seem on first thought that it applied to animals which have only one offspring at a time. But it has been found that there is in reality a great deal of uterine death.

Whatever may be the true explanation, when it is found, may possibly be used by man to influence the proportion of the sexes born, but I believe that it is very doubtful. Especially if the proportions are due to uterine death, it would be necessary to kill some of the young in utero and surely that would be no advantage.

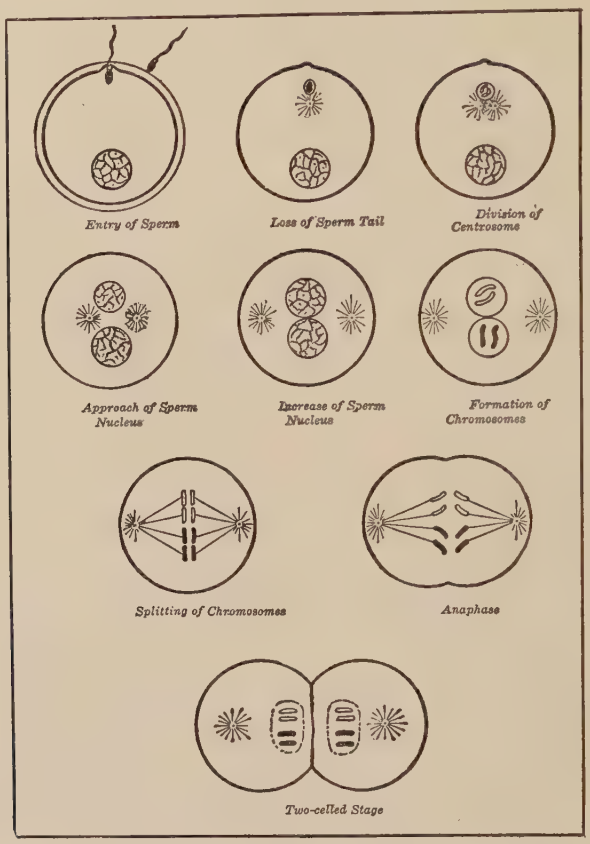
Furthermore, the experiments with alcoholizing guinea pigs demonstrate that while alcohol did have some effect upon the vitality of the survivors, it did not alter the proportions of males and females.

FERTILIZATION

The sperm works up along side of the ovum by the wiggling motion of its tail, the head penetrates the wall of the ovum, no doubt with the help of the ovum, the nucleus of the sperm enlarges until it has become the size of the nucleus of the ovum. The centrosome divides and one goes to each side of the two nucleii.

Then the network breaks into chromosomes. Each chromosome divides. The wall surrounding them disappears and curiously enough the wall of the cell becomes constricted, a division forms right between the two sets of chromosomes and the two cells thus formed each have half the chromosomes of the original pair but now they are combined and each of the new cells is a complete perfect cell with twenty-four complete pairs of chromosomes.

We have therefore gone the whole cycle of the cell from its beginning until we have again arrived at our starting point.



The intricate process of fertilization. (From Walter by Boveri)

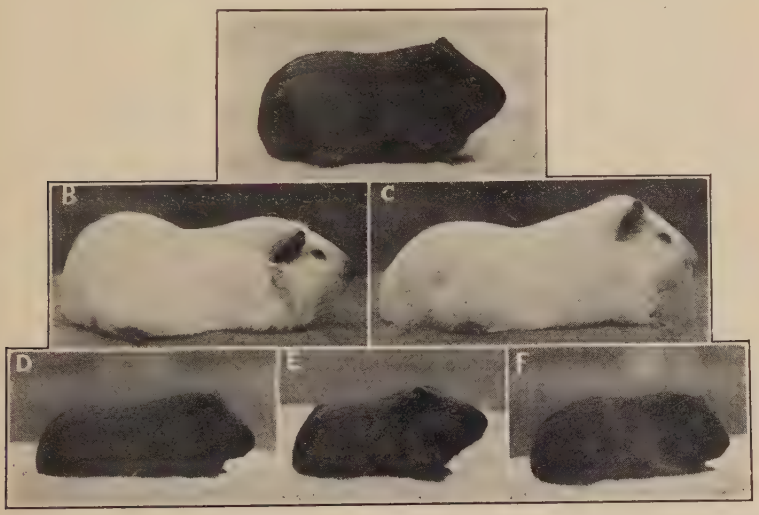
There we leave it for a few considerations which are pertinent to this question of the cell.

One of the things we should remember especially is that the germ-plasm is isolated from the rest of the body and is nourished by the blood of the body. It creates the animals, and is not created by them. It is almost entirely immune to any influence from without.

Dr. Castle of Harvard removed the ovaries from a young white guinea pig. It was a pure bred individual. In place of them he grafted a pair of ovaries from a black guinea pig. He waited a year, until he felt sure that if there would be any effect upon the ovaries, it would be complete. Then he mated the white guinea pig to a white one.

Now never before in the history of guinea pigs has a white guinea pig when mated to a white, produced anything but white guinea pigs, as we shall learn later when we study Mendelism. But Dr. Castle raised all black guinea pigs from this white mother. Neither her blood, her secretions, nor anything else has been able to change the potential color of those cells within the ovaries, and they probably never can.

The germ-plasm of the male is no less unchangeable by him. Thus far, it has been found that certain chemicals and toxics,



Prof. W. E. Castle transplanted the ovaries from guinea pig A to guinea pig B, which he later mated to C. Guinea pigs D, E, and F are the offspring. The ovaries from the black guinea pig were thus unaffected.

such as arsenic, and alcohol, and diseases such as syphilis may have some effect on it, but these are not the secretions of the animal, and the effect is to kill the sperm and ova.

So we can see how ridiculous is the talk about blooded heredity. Of course we have none of our ancestors blood

coursing through our veins. What we should say is, "*I have some of his genes in my cells.*" Then we would be telling the truth.

Another interesting observation here is the relationship of mother and father to offspring. It has direct bearing on the question of inbreeding. For instance, we see that actually a father is half brother to his offspring. The offspring receives half of the chromosomes from the father and half from the mother. An animal's half brother is therefore the same relation to him as is the parent which sired both. I have often made my father smile by calling him, "half brother." But that is a mechanical fact. And my mother is my half sister.

The relationship between brother and sister is therefore greater than the relationship between parent and offspring—a fact seldom understood by those who profess to know about inbreeding.

CHAPTER VII

THE INHERITANCE OF ACQUIRED CHARACTERS

Some years ago the scientists themselves were having heated arguments over this question: "If a man by some means becomes changed during his lifetime, can he pass on that change, in any degree to his children?"

Most people today believe that he can.

Recently, I heard two men talking about buying a whole litter of pups, from a third. One of them said, "I would pay any price within reason, that he might ask for that litter."

This bitch was hunted regularly while in whelp. Would her pups be better hunters, therefore ?

When pressed for his reason, I heard that this man had been hunting with the bitch during the time that she had carried a litter of pups, and she had hunted the entire time, in fact right up to the last night. The man felt positive that those pups would develop into much better hunting dogs because of this fact.

Lamarck is really the father of the theory that acquired modifications of the body are inherited.

Some years ago a Chicago lawyer named Casper Redfield, a charming, intense and sincere gentleman, defended this theory that if an animal by its own efforts gains in bodily strength or ability, that it will be able to pass this gain on to the offspring. He wrote much about the theory. He spent years in going over the records of trotting horses and concluded that the longer a horse had raced, the faster his offspring were.

He spent more years going over the records of the Holstein Friesian cattle and found that the older the cows were at the time of calving, the more milk their calves would produce. He found the record of the origin of the Laverack setters and concluded that they were developed into great hunters because the originator had waited until his dogs were old, and then raised pups from them. The pups were supposed to have inherited the accumulated skill of their parents.

Then Mr. Redfield proceeded to examine the persons who were listed in the Hall of Fame. He found that the reason they were there was because they were the sons and daughters of very old fathers. Then he proceeded to write and distribute his writings on his discoveries far and wide.

Casper Redfield was for many years the champion of "acquired characters" in America. He proclaimed that the reason we have so much crime in America was because the people marry too young. The reason the educated classes produce a uniformly higher class of children was, in his mind, because they studied long and married late. Indeed the theory sounded plausible.

But it has come to grief on the rocks of investigation. First the scientists found that what he had proved about cattle was not true. Dr. Charles B. Davenport made a similar investigation of the cattle and found that there was no difference in favor of last calves over first calves. Then the horse theory was completely disproved by Dr. Harry H. Laughlin. Dr. W. Key investigated the last forty persons listed in the Hall of Fame and found that whether they were the first or last child of their family had nothing whatever to do with their success in life. Other strains of setters are believed by many to be as good as the Laverack, and Mr. Redfield's theory is pretty well disproved.

No scientists, however, will say dogmatically that there is nothing in it. In the first place, to say that would be simply to renew an argument which for the time has died down to

practically a whisper. The concensus of opinion of those who ought to know, I believe, is this: that if there is anything to the theory of the inheritance of acquired bodily changes, it has not been demonstrated. Some scientists are waiting for a proof, others are frank in saying that the idea is nonsense, and if it were a fact the race of man would have long ago been extinct. Others are searching out the facts.

So far as we are concerned it will be best to take the attitude that there is nothing to the idea. If there is, then it has not been proved to the satisfaction of nearly one hundred per cent of the scientists; if there is, it is so slight that it does not concern us.

Let us consider a few of the general facts and then we shall give our attention to the theory as it applies to our animals.

Changes in the germ plasm caused the changes in species and the changes in the breeds. What caused these changes in the germplasm no one knows. Recently Dr. Muller, and others have induced changes in certain species by X-rays, but none of these changes have been improvements on the old forms and most of them have been known to have appeared in laboratories before.

Many thousands of years ago the first cat was domesticated. It was no doubt taken when it was a kitten. Since that time the purring pussies have been lying on laps of millions of women; they have been living in houses and have stretched out before as many hearth-stones in front of blazing fires.

If this care and domestication could be inherited, today the cat would be the most loving, docile animal imaginable. Is it? If becoming acquainted with fire would tend to make the kittens less afraid, they would fear it less and less, but do not cats still have to be taught not to fear fire?

Several years ago I was trapping some miles away from the nearest house. I caught a wild ferocious cat in a trap, which proved to be my wife's long lost pet that had spent its first five years in a city house without ever having climbed a tree. That same winter I trapped six cats in the woods and all were as wild as bobcats. They were either born in the woods or had left their civilization and gone to live the life to which they were fitted, living in holes in the ground and killing relentlessly.

Certainly the acquirement of domestication was not inherited in these cases, and cats are notoriously undomesticated regardless of how docile they may seem. The wild traits are

there and they enjoy catching the canary as much as their ancestors thousands of years ago in the wilds of Persia, enjoyed killing birds there.

Looking at the question from the other side, let us see the effects of disuse. When I was a boy, I purchased a pair of homing pigeons from a squab farm. Now the ancestors of

Skins taken from wild house cats. Cats have not inherited the cumulative effect of hundreds of years of domestication.

that pair of pigeons had for over ten generations never flown for more than forty feet consecutively. Their cage had been but twenty feet long and they had for generations been kept as breeders of squabs for the table. In fact, it may have been for twenty-five generations that this had gone on, as the manager of the squab farm had been in the business a long while and had been selling breeding stock as well as table squabs.

I took my pigeons home with me, mated them, put the young in with my other homing pigeons and trained them with the rest. In time they were raced with the birds from a

great homing pigeon club. Six hundred birds were liberated one hundred and fifty miles from home, no bird being over eight months old. A bird from one of these meat pigeons was third in the race in almost record time. And more than that,

A great homing pigeon, whose ancestors had been kept in confinement for many generations

all of the birds from that pair returned, while several hundred birds from parents which had been famous racers never returned.

A beautiful pointer dog came to my attention. She was one of those sensitive quivering animals, and she had been handled by a person too free with his alcoholic spirits. He had made her into the most gunshy bitch imaginable, almost worthless. As it happened she was mated to another gunshy dog. But the pups were handled by an expert and today there are few finer shooting dogs alive. Her acquired trait was not inherited, nor was the double of it inherited.

This is not advocating the mating of gunshy dogs. It may be dangerous practice, but that instance is the result of one of those matings. There are several instances which have come to my attention, of gunshy dogs which were used as bench dogs, but with the proper handling they made excellent field dogs.

The nervous temperament which succumbs to gunshyness is inherited. So is the phlegmatic one, which would not stir at the report of a cannon, but they are not inherited as the result of the actions of the ancestors. They are the result of selection.

Mutilations are not inherited as far as can be determined. Recently a breeder wrote me that he had finally produced a tailless Boston terrier. He said he had been treating the tails of his pups for several generations and now one was born which showed the effects of this effort.

There is another explanation for this, however, which we shall see when we take up mutations. Men have been docking dogs' tails almost since there have been dogs, they have been trimming the ears, and still the tails continue to grow long and the ears as they would have been, had the ancestors' ears never been touched. Tails of sheep have been docked as long as history records and still they keep on coming with nature's regulation length.

A German scientist, August Weismann, cut the tails off mice for twenty-two succeeding generations and it had no effect upon the final product. Some races have long been practicing mutilations of the body but the children are in no way affected by it.

We have seen the construction of the germ plasm and how the genes are the determiners of the future animal. If acquired characters were to be inherited, there would have to be some means at the disposal of the body to change the germ plasm. So far as can be determined there is no means. The germ plasm is sufficient to account for the method of inheritance as we have seen and shall see. There is no need to look for other means, and it is very doubtful if there are any.

Can acquired diseases be inherited? Not any known diseases of animals. Venereal disease is inherited in man, but not in animals. Even then the disease itself is not actually inherited but is contracted at birth. It does not work into the germ cell.

Rickets was formerly considered an inherited disease and sometimes a disease which could be acquired and then inherited, like cretinism in the human. When the settlers went to Michigan, they took with them flocks of sheep. Dr. John Harvey Kellogg of Battle Creek, told me a very interesting experience he had as a young man. His father was losing a large percentage of lambs because they were born with immense thyroid glands. The farmers all about the section thought this condition was inherited just as the Swiss people of the Alps thought. But the young Doctor, had an idea.

He went to a salt mine miles away, which he knew to contain iodine, and brought home some of that salt. The next batch of lambs were born perfect. From that time on his father raised healthy lambs because he used that salt.

Near seacoasts where fish are plentiful in the diet, the people seldom have goitre, and now in the inland regions which are short of iodine, it is taken in some manner to avoid thyroid trouble.

In the Alps, the cretins were greatly reduced within a generation by an education campaign teaching pregnant women that they must include some form of iodine in their diet. Cretins are abnormal, dwarflike people who seldom live to be over thirty-five years old. Their condition is brought about by a lack of iodine in the pregnant mother's diet.

We can easily imagine that, had a breeder bought some sound dogs that raised a lot of rickety pups, he might think they had contracted the disease. Then if their pups grew up to be rickety also, he might conclude that the acquired defect was inherited. But the trouble would be in the fact that the breeder had not fed his pups properly, and they developed bones which were abnormal. This would apply to all the pups he raised.

I would not hesitate to use a rickety dog in my breeding if I were certain that rickets was the cause of his defect. The pups would be as sound as though the parents had been unaffected.

Disease is not inherited, but the predisposition for certain disease is inherited. In the human, tuberculosis "runs in families." It is not inherited, but the individuals lack some constitutional factor which allows normal persons to throw it off even though they may be caring for a person afflicted with tuberculosis, breathing his breath, and in general exposing themselves. And strangely enough the tendency is inherited. Cancer is not inherited, but the ability to withstand it is.

Dr. Maud Slye of the University of Chicago has for years been experimenting with mice to learn about the inheritance of cancer. She has not only worked out the mode of inheritance but has learned that susceptibility to different forms of cancer is inherited likewise.

Dr. C. C. Little, President of the University of Michigan, has found certain families of mice that he has isolated until he could not infect them, even though he inoculated them with cancer tissue. He has others that develop it normally.

This is part of the selection of the races which has gone on for nobody knows how long. It is easy to imagine that when the human race first contracted measles, that they died off like flies. Today measles is no dreaded disease. It is a comparatively simple eruptive disease of childhood.

But consider the wonderful race of Hawaiians. They had never known measles until the white men went there, and when they were exposed, they died as by the plague. It reduced that fine race to a mere skeleton of what it once was —this, our comparatively mild disease of childhood. To measles is in part attributed the devastation of the Hawaiian race.

In the future we may be able to isolate certain strains of our present breeds of animals so that they will be immune to some of their diseases. But today the races are so mixed, and there has been so little chance for selection, that animals of all breeds are subject to most of the diseases of their species Some, perhaps, are less affected than others, and some may be immune. Time alone will tell.

In studying the effects of alcohol on the systems of animals, Dr. Charles R. Stockard and Dr. G. N. Papanicolaou of Cornell University, discovered that they could definitely influence the young and that alcohol affected the germ plasm, just as many poisons would have done. No doubt illuminating gas would have produced the same results. They put guinea pigs in a tank which was filled with the fumes of alcohol. There they remained until they were intoxicated. This was repeated every day until there were five thousand individuals which had been so treated.

Males which had not been treated were mated to females which had. Females which had not been treated were mated to males which had. After continuing the treatment for some years the summaries showed that the alcohol killed off the weak specimens. Some died before birth and were partially absorbed. Others died after birth.

When the experiment was completed it was found that the remaining guinea pigs were stronger and better than the original pigs. Apparently the alcohol had weeded out the weak but had not been able to affect the strong. But in doing so, it did not alter them. So even alcohol does not permanently affect the germ plasm of the race. It merely selects the weak and destroys them.

Dr. Raymond Pearl made the same kind of tests on chickens, in Maine. He found that he was able to select a strain of

chickens that was stronger than the original ones by intoxicating his stock every day. Apparently the alcohol weakened the germ cells of the poultry so that some chickens did not develop into matured fowls, but died in the shell, and the very weak germ cells did not become fertilized or were not able to fertilize as the case might be.

Every child and all of our animals have to learn all over again the things that we learned and the things our animal's ancestors learned because such efforts do not impress the germ plasm and so it shall no doubt always be. Professor Edwin G. Conklin of Princeton has put the whole thing in a nutshell when he says, "wooden heads are inherited, wooden legs are not."

For these reasons pups which have been carried by a bitch while she was hunting, are no better for hunting than those born to her when she has not hunted.

The racing of horses does not make their colts faster; forcing cows to give great quantities of milk up to their limits does not make the calves better milk producers; forcing beef cattle to fatten, or racing pigeons, does not give their offspring more ability along their respective lines. *What it does do is to bring out their abilities so that the best may be used to sire or bear the next generation.*

Pups from old hunting dogs are no better hunters than pups from first litters, providing there is equally good heredity. Racing whippets does not make them better able to pass on increased speed to their offspring. Docking tails does not make them shorter. Cutting ears does not make the ears better or smaller. It makes them worse by eliminating the chance for selection. Housebreaking animals does not induce habits of cleanliness in succeeding generations.

It is commonly supposed that the young from the second or subsequent pregnancy of a female will be better than those of the first. Somehow people got the idea that if the first mating cycle were skipped that the young would be better. Right here let me state that the whole theory is founded upon sand. There is no demonstrated truth in it as far as the offspring are concerned. It might just as well be said that the first season's eggs from a pullet would not hatch as good chickens as the eggs from later seasons.

And when thinking about this question, if we always keep in mind the simile of the hen and her eggs, we are not so apt to go astray in our reasoning. No one would think of sug-

gesting that the hen could transfer any nervous impression to the developing chicks in the eggs under her.

If we were to put them in the incubator and hatch them, we could expect to have as good chicks, as capable egg producers, as desirable meat producers, and as intelligent chickens, as if the hen had hatched them.

When young animals are in the womb of the mother, they are isolated from her practically as much as they are while they are still nursing. True they are within her and well protected and warmed by her, but all that they receive is nourishment and warmth. There is no nerve system connecting the young and their mother, and there is none of the mother's blood running through their veins. So to all intents and purposes they are like the eggs under the hen with the exception that the eggs are laid with enough nourishment contained along with the fertilized ova to feed the chicks for three weeks, while the young animals have to receive it as they grow.

Were there any known way of furnishing nourishment to the developing young, and they were to be raised in incubators, we might expect that they would turn out fully as well as though they had spent the foetal stage of their lives within the mother's womb.

In the future, therefore, let us not put the cart before the horse. Instead of assuming that exercise of the various special abilities of the breeds has affected the germ plasm, let us remember that what the exercise has done, is simply to demonstrate what individuals were best fitted for the purposes for which we needed them. Selection of demonstrated qualities, not the inheritance of acquired characters by the individual, has improved the breeds of our animals, birds, and plants.

CHAPTER VIII

MENDELISM

In 1859 in a little garden behind his church in Brunn, Moravia, a clergyman, Gregor Mendel, conducted some experiments with garden peas. He knew nothing about the genes and chromosomes, but he did make a discovery which

Gregor Mendel, a great scientist and the author of Mendelism.

was revolutionary in its nature. His experiments covered several years, and when he had concluded them he recorded his findings and the short paper was published in an obscure little journal of natural history.

The idea was so new, and Mendel was so far ahead of the times, that the paper was forgotten. Not until 1900 was it brought to light. In the meantime new discoveries had been made, which caused the scientists to have a better appreciation of the importance of Mendel's discovery.

To review the work briefly, we must start with the original plantings. There were two kinds of garden peas. One was

brush peas (talls) and one was dwarf peas. Now it happens that the pea will fertilize itself and that it is also very easy to fertilize a blossom artificially with the pollen from another blossom.

So Mendel wondered what would happen if he were to mix the breeds of peas. Having plenty of time, he took pains to fertilize the dwarf peas blossoms with pollen from the talls', and vice versa. Then when the seeds were ripe, he saved them until the next season and planted them.

Naturally he might have expected to get peas which were in size half way between, but he did not. Instead he found that every pea vine was tall, like the tall parent. Therefore he said to himself, "these peas had two parents, and each must have contributed half, so in reality they are half breeds, but

The little garden in Brunn, Moravia, in which Mendel made his revolutionary experiments.

the tallness dominates the dwarfness; it appears, and the dwarfness recedes from view, but it must be there, nevertheless. I shall call the character which dominates, the dominant; the character which recedes, the recessive."

The next year Mendel left the pea vines alone, and, of course, they pollinated themselves. This was the F1 (first fam-

ily) generation. They were mating within the family, about as brother to sister. Again he saved the seed. Again he planted them. What did he find? This time he had both tall and dwarf peas. There were no intermediates. When Mendel counted he found there were twenty-five per cent dwarfs and seventy-five per cent talls.

The next year Mendel planted these dwarfs and talls. All of the dwarfs bred true, but of the talls some also bred true but more of them behaved just as their hybrid parents had. To make a long story short, Mendel kept breeding and planting peas until he had determined that when he planted peas which were the result of a tall crossed with a dwarf, he would get twenty-five per cent pure talls, twenty-five per cent pure dwarfs, and fifty per cent halfbreeds, or hybrids, like the parents.

We can imagine his astonishment, but we have an advantage which he did not have. We know about the genes, and that they always go in pairs. We know that some of his tall peas possessed a pair of genes for tallness and the dwarfs all had pairs for dwarfness. We can see that when the pollen grains and the ova were formed that one gene went into each.

Then we can see that when the pollen from the tall mated with the ova from the dwarf, that the resulting cell had one dwarf gene and one tall gene. Because tallness is dominant, the resulting vines which grew from these cells were all tall.

We see also that when the pollen cells were formed from these, that one cell would receive a gene for tallnss and a gene for dwarfness. So would the ova. We can therefore explain why it is that the vines were not all tall or why there were no intermediates. It is simple arithmetic. If we represent tallness (the dominant), by T, and dwarfness (the recessive) by t, we see that it works out as follows:

In the parent generation a T would always combine with a t. The resulting offspring would always be (T t).

In the first family generation F1 there are four possibilities for the genes combining. A T might combine with a T; a t might combine with another t, or a T might combine with a t in two instances so we would have (T T), 2 (t T), (tt).

	T	t
T	TT	Tt
t	Tt	tt

TT + 2Tt + tt

Therefore we see that the plants which received by chance the two genes for tallness would be tall and would always produce tall pea vines. The ones which received two ts would be pure for dwarfness and could produce nothing but dwarfs, while the ones which received a T and a t would be just like the parents and if mated togther would produce the same proportion of mixed offspring as the parent or F1 generation.

In nature there are a few instances of imperfect dominance. When a black Andalusian fowl is mated with a white, the resulting chickens are blue.

Another case of incomplete dominance is that of shorthorn cattle. A red and a white produce a roan calf. Roans will produce reds and whites and roans in the Mendelian proportions when a large enough number of cases are considered. The whites and reds are pure and will henceforth breed true.

Aside from a few of these cases of incomplete dominance it is impossible to distinguish the hybrid from the pure dominant and the only way is by examination of the offspring. This is usually easily done by mating a dominant with a recessive and if all of the young do not possess the dominant trait one may be positive that the parent in question is a hybrid.

A blue ticked hound. The factor for ticking is dominant.

Here, for example, is a picture of a hound. I had learned that the blue ticking was a simple dominant. I wanted to

know whether he was pure for this trait; that is, whether both genes which determined it were dominant genes. So I mated him to a non-ticked bitch. Three pups of the litter were ticked and four were non-ticked, so I knew what to expect in the future.

Now to make a further practical application, let us take the foxhound puppies in the picture. The mother had one black and tan ancestor and one tri-colored. So did the father. The litter of nine pups has two that are tri-colored, which is pretty

Recessive tri-colored puppies appearing in a litter of black-and-tans.

close to twenty-five per cent. The tri-color is recessive to black and tan and thus we see the comparison to the pea vines.

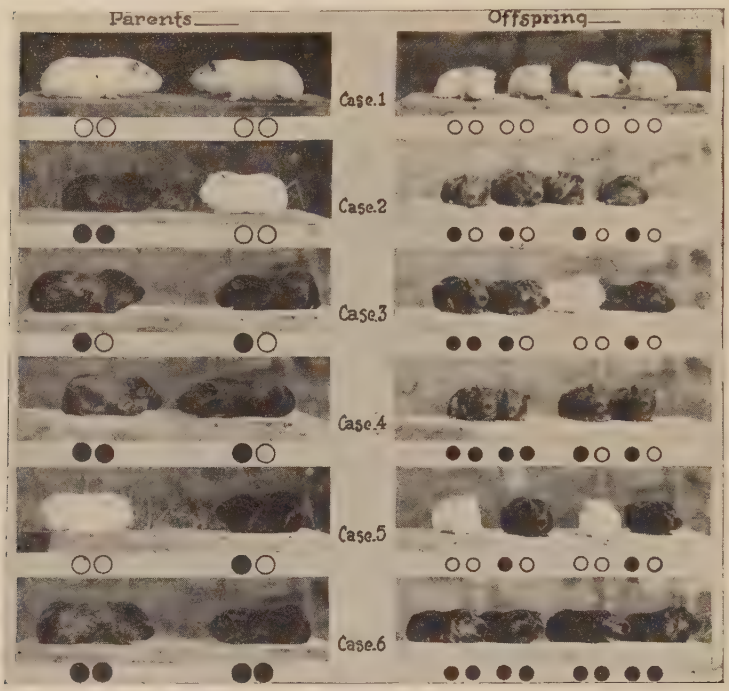
The following pictures of guinea pigs show all of the six possible ways in which black and white guinea pigs can combine. It also illustrates the genes by the black and white circles. It shows how nicely Mendelism operates in animals that have only a difference of one gene for a trait.

When a white guinea pig is mated to a pure black, the offspring are always black. Therefore, I mated a pure black with a white. There were five young blacks. Obviously each of these had one gene for white and one for black in the pair which determined the color. I mated two of these young when they were grown. The illustration shows the result; the black mother and father with three black young and one white. The expected proportion arrived in one litter.

These were guinea pigs which I bred for exhibition purposes for the American Eugenics Society. I wouldn't have anyone believe that each of the litters came as nicely according to expectations as appears. This illustration might give the reader the idea that of four offspring from Case 3, for in-

stance, they would always be born in the proportion of three blacks to one white.

Such is not the case. In one litter there might be two young, one white and one black or there might be six, all black. The diagram is idealistic only, and shows the chances. It would be better if we could show a thousand young from



All of the six possible ways in which black and white can combine. The circles beneath the guinea pigs represent the genes in the germ plasm.

matings and then show two hundred and fifty white and seven hundred and fifty black. That would be the expectancy.

The same applies to one litter if it happens to be of four—that is the expected proportion, but in actual practice it is not always realized. One of my hybrid black pigs when mated to a white (Case 5) produced six white in two litters when I expected fifty-fifty (half black and half white). If I had continued long enough my fifty-fifty ratio would in all probability have been realized.

So, when we say one-fourth, one-half, etc., we do not mean that we must expect to get those proportions from each litter, or from each family of children. That applies to large numbers. It simply means that *the chances*, as each child is born, are that he or she will be according to certain expectations.

When we consider this pair of color-determining genes alone and look for all the possibilities, we find there are six. We shall call black, B and the absence of black, or white, b.

If the male had one gene for black and one for white in his germ cells, obviously the sperm formed from that cell would have either a white or a black when the chromosomes divide. The same principle applies to the ova.

1. If a white mates with a white, then we would have:

(b	b)	white
(b	b)	white
4 (b	b)	white

2. A white might mate with a black, and as we have seen, we should have:

(b	b)	white
(B	B)	black
4 (B	b)	halfbreed (appears black)

3. A half breed might mate with a halfbreed, as we have seen:

(B	b)	halfbreed (appears black)
(B	b)	halfbreed (appears black)

(b b)	2(B b)	(B B)
white	halfbreed	black

4. A black might mate with a halfbreed:

(B	B)	black
(B	b)	halfbreed (appears black)

2(B B)	2(B b)
black	halfbreed

5. A white might mate with a halfbreed, and we would have:

(b	b)	white
(B	b)	halfbreed (appears black)

2(B b)	2(b b)
halfbreed	white

6. A black might mate with a black:

(B	B)	black
(B	B)	black
4 (B	B)	black

These are all the possibilities. The law applies to any trait of any animal or plant when there is a difference of only one gene.

Imagine that these genes are so many black and white beans in a hat. Half of the beans are contributed by sperm and

half by ova. You are to reach in the hat and select these beans two at a time. You get certain proportions, depending on the proportions of the different colored beans in the hat.

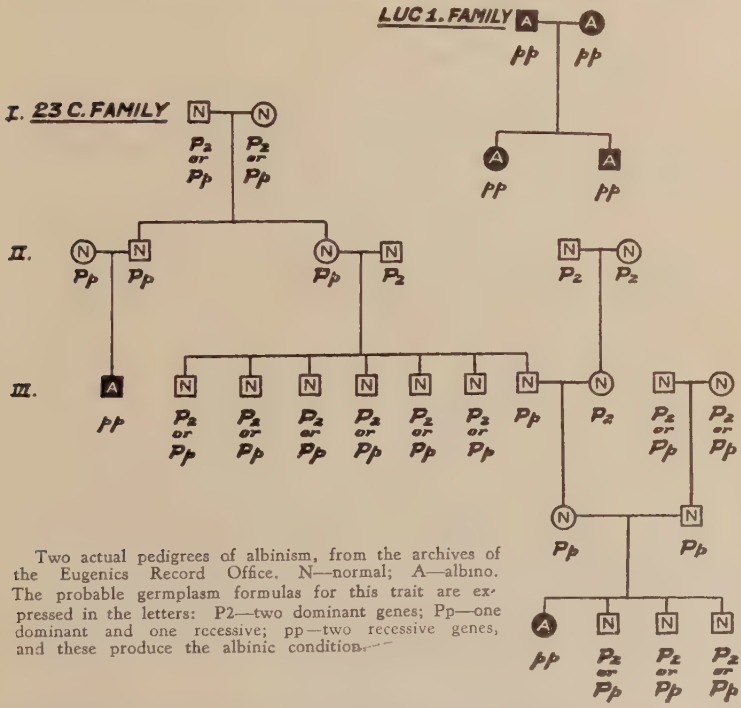
In regard to the ticking factor, these pups are comparable to Case 5 of the guinea pigs on page 54. One of their grandparents was ticked; three were not. About half of the litter of which these pups were a part was ticked, the rest not. The upper two pups are just beginning to show the ticking, which appears at about the age of four weeks.

If all white beans are in the hat you will always draw pairs of white ones. But when they are mixed you may get two white, or two black, or one of each.

Take, for instance, human eye color. Brown eyes are dominant over blue. Two pure blue eyed persons will have blue eyed children, always. The brown eyed parents which have no gene for blue will have brown eyed children. A blue and a brown, if the brown is pure, will have all brown eyed children, each of which have a gene for blue. The parents, each of whom have one brown gene and one blue gene (they will both be brown eyed) may have one-fourth pure brown eyed children, one-half like themselves, and one-fourth blue eyed children.

Dominance and recessiveness are totally independent of sex. It makes no difference which sex carries the dominant trait—the results are the same (except sex-linked traits).

The age of a trait does not appear to have any influence upon its dominance. Frequently I hear men say that the



Two actual pedigrees of albinism, from the archives of the Eugenics Record Office. N—normal; A—albino. The probable germplasm formulas for this trait are expressed in the letters: P2—two dominant genes; Pp—one dominant and one recessive; pp—two recessive genes, and these produce the albinic condition.

pointer is an older breed because when mated with a setter, the short hair is dominant. This age factor is not a criterion,

however. Polled or hornless cattle are a new variety, and yet hornlessness is dominant over presence of horns.

In dogs the open trailing quality is dominant over the silent trailing, but no doubt the original dogs were silent trailers. Otherwise they would have had less hope of catching their game if they ran along barking at them or if they barked at a distance when they first struck the track, the game would have a wonderful chance to get out of the neighborhood.

Right here we can see how it is that some traits drop out of the germ plasm and are lost. When a recessive trait seems to be lost it may not be, because it may be concealed by the dominant. But when a dominant trait does not appear in the offspring it is lost completely from the germ plasm. When two hybrid black guinea pigs produce a white one, the black is gone completely from the germ plasm of the white and it cannot pass on the black color of its parents because it has no black determining genes in its germ cells.

The recessive may also become lost but the only possible way to determine that is by breeding to another animal which will have a germ plasm constitution that will bring the recessive to light in the offspring. If it does not appear we may be sure the animal is pure dominant.

There are some genes which are known as lethal (killing) genes. As yet there are none known except in laboratory animals, although some may be discovered. But in the mouse, for instance, yellow is a lethal. Thus far it has never been possible to raise a pure yellow mouse. The reason is that when two of the yellow producing genes become paired, the offspring dies in a few days after it is conceived.

This was very puzzling for some years, until it was observed that the size of litters of two yellow mice was uniformly about one-fourth smaller than when they were mated with mice of other colors. An examination showed mice dead in embryo.

It may be that there are lethal genes in the domestic animals. Every breeder should be on the constant lookout for them. If it seems impossible to develop a certain trait which will always breed true, the fact should be reported so that other breeders can be on the watch.

The units of most of the laboratory animals such as mice, rats, rabbits, guinea pigs, have been worked out, until there is a great deal known about them. There are very few ordinary

traits about them which are not known. The scientist can predict the outcome of any given matings within very narrow limits.

Dr. Donald F. Jones of the Connecticut Agricultural Experiment Station has likewise bred corn until he has factored it into a great number of genes, each of which determines a trait, or else works in conjunction with certain others to determine the trait.

As pretty an experiment as one could wish to see is the one in the illustration, of the corn plants. Dr. Jones has found a gene which makes the corn plant dwarfed, in a certain way, as represented by the dwarf at the left. He has found another separate gene which dwarfs the corn like the plant on the right.

The two dwarfs, when mated, produced the normal sized corn in the center.

Both of these genes are recessive and therefore they must each be paired in order for the corn to be dwarfed. The Doctor mated these two dwarfs and saved the seeds for

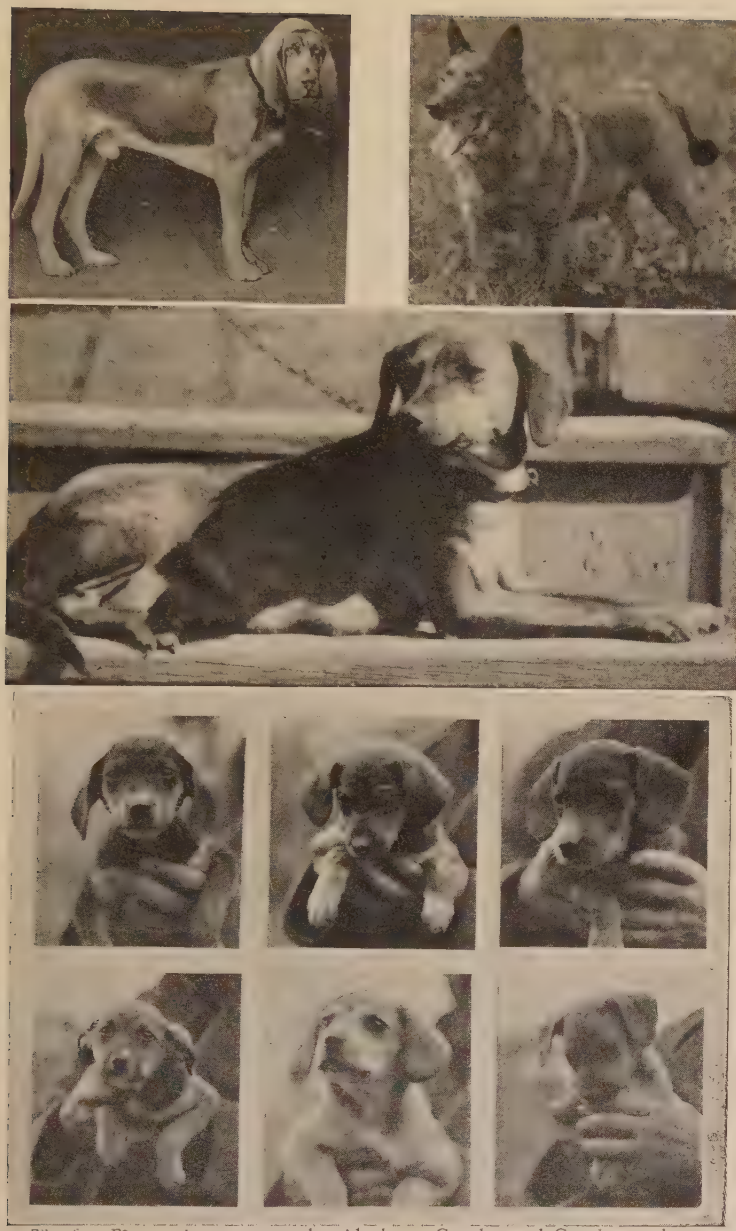
another year so he could plant all three and so illustrate what happened. The cross between the two dwarfs would have one normal gene and one dwarf gene paired off together, since the two kinds of dwarf producing genes are located in different places on the chomosome. Look at the results of the cross—normal corn.

But Dr. Jones went further. He mated this apparently normal corn the next year and found that he had normals and dwarfs in the expected proportions. Every here and there along the rows were some tiny corn plants which were not much over six inches tall. These little things had received one pair of the genes which caused one kind of dwarfness, and one pair which produced the other, so they were double dwarfs, and very pathetic.

It will take generations before a large proportion of the unit genes for all animals are discovered. One realizes the complexity of the task when one attempts to learn some of them for even one animal. Learning as many as possible for the dog has taken so many hours of my time that I fully realize what is in store for the investigator who attempts the study with larger animals. Some of the traits which appear to be unit traits eventually prove to be governed by multiple genes which must sooner or later be factored out. Fortunately in some instances we can learn much by studing records of matings already made. Keeping animals for the discovery of unit genes is expensive but the results are often interesting.

Look at the illustration. There was a great difference in the bloodhound and the elkhound—about as much difference as could be found between dogs, in many respects. The dominant traits which this crossing brings to light are the following: tan of the bloodhound dominant over the grey of the elkhound; long black guard hairs of the elkhound dominant over the lack of them in the bloodhound; lop ears of the bloodhound dominant over the erect ears of the elkhound; open trailing quality of bloodhound dominant; quality of elkhound's voice dominant over the drawl of the bloodhound; peppy, alert, active disposition of elkhound dominant; straight tail of bloodhound dominant over curly tail; keenness of scent of bloodhound recessive; thick coat of elkhound recessive to thin coat of bloodhound. Where not mentioned, of course the corresponding qualities are recessive or dominant.

It is also interesting to notice that in the mating of the pups from this pair, how the traits in their young have recombined.



The first F2 experiment ever made with dogs. Grandma and Grandpa at the top, produced mother, who when mated to her brother produced the six pups. Note how the grandparents' traits have recombined in the pups.

Take the first pup, who has a fairly typical houndlike appearance in all respects. Now that he is grown, his ears are not long enough, nor is he large enough to be a good bloodhound. He has turned out to be an excellent fox hound.

Look at number five. He has fairly long ears, but the thick coat of the elkhound, and his tail made an attempt to curl over his back, but grew too long and heavy. His color is like the elkhound, but entirely lacks the black guard hairs.

It should now be clear that the traits which go into a mixture do not always come out in the same combinations as they went in. It should also be clear that although these tiny genes have been working side by side with other genes which might be as different as can be, that they have not become in the least affected by the other. They work in harmony but when they separate they are just as they were when they entered.

This is the biggest lesson of Mendelism next to the lesson of dominance and recession. Think of these genes as so many beans in a hat. You can mix them around but when they come out they are still beans and not affected because they have rubbed against each other, or worked together.

If the parents each have a certain number of genes in their cells and they each give half of them to the offspring, why, a person may ask, is not every offspring just like the other? That is reasonable objection. Obviously each offspring must have received a different assortment of genes in order to differ as they do. The greater likeness in the assortment of genes received, determines the closeness of resemblance among the offspring.

In order to bring out the result, there must be some mechanism for accomplishing it. For example, if a long haired black dog mates with a short haired white, the pups are born with black short hair. If two of these are mated a pup may be born with long white hair. This would be due to a different assortment of chromosomes received when the new segregation took place.

How many times have breeders been disappointed by finding several young in a litter which did not begin to approach the desired standard! Many a man has taken some female miles away to some prize winner, and paid a large fee for the service, only to find that she had given birth to a large propor-

tion of young, or to a colt or calf, which were not as good as either of the parents.

This is not hard to explain. Where there are allowable differences in the breed, the young which are different are so because the traits which appear are recessive.

The puppies above were from this pure bred foxhound and a sable and white collie. Note that the pups received some traits from each, but the color wholly from the collie.

CHAPTER IX

SELECTION: AND THE MECHANISM OF INHERITANCE AND EVOLUTION

At this point let us digress to inquire into the more mechanical phases of the business parts of the cell, the chromosomes, and their part in the origin of species. This will make the subject of Mendelism clearer. When one can have a mind picture of what is happening with the thing he is considering, it is much easier to understand.

This study will also give a better understanding of how man has been able to so greatly change the breeds of domestic animals to suit his needs or fancies. By selection of changes which came about by some means which our forefathers did not understand, the multiform breeds of today have come into existence.

Nature made the changes in man himself, but man has changed his animals from the diminutive pony to the giant draft horse, from the range cow to the 30,000 pound milk producer, from the razorback to the Berkshire swine, from the jackal or wolf to the bloodhound, from the junglefowl to the 330 egg-per-year hen, from the rock pigeon to the homer with his great endurance and homing capacity. How were these changes possible? Something must has happened in order for man to have been able to make them. What was this?

Since we accept the gene and chromosome theory as basic, believing that the chromosomes are the hereditary bridge between one generation and the next and that they are the only bridge, then if a change appeared in the offspring which proved not to have been a part of the parents, we must explain it in one of two ways: either it is a combination of recessive characters or it is a change in the chromosomes or the genes which constitute them.

Persons who do not understand genetics constantly refer to "sports." If they find among their animals a new type or even a difference of a single trait from the parents, they say they have a sport. Since a sport might be caused by a combination of recessives, or by a germinal change, the term is too inaccurate to be used, and should be forgotten.

If the change which appears is caused by a combination of recessives, that is surely nothing which is unusual and in reality is not a change but simply a reappearance of something which has existed for some time in the germ plasm. If

The change from the razor back hog to the modern Chester white, is prodigious. (From U. S. D. A. Dept. Animal Industry)

the change was caused by an alteraton of a cell then it may be permanent or it may not be depending upon the position of the cell which changed. No matter where it was located, this

permanent change caused by alteration of a cell or cells, is called a *mutation.*

If the change occurred in the germ plasm then it will be inherited and this change will be passed along to future genera-

Man has made the gulf between the bloodhound and his early ancestor wide indeed, not only in appearance but in mental traits.

tions provided that it is not lost in the reduction divisions of the sperm or ova. If it occurred in the body during development, it dies with the individual.

Furthermore the change in the germ cells may be of several forms. One of the most usual, because most noticeable, is the appearance of albinic animals. These have lost the color pro-

ducing factor, and the phenomena occurs in all sorts and conditions of plants and animals. The laboratory animals frequently mutate. One investigator has had three definite color mutations among the rats used. The number of these among fruit flies seems to be about one in every 50,000 individuals.

The mutation may be caused by the change in a single gene or by a group of genes, or by the change in position of different parts of a chromosome. Or it may take the form of

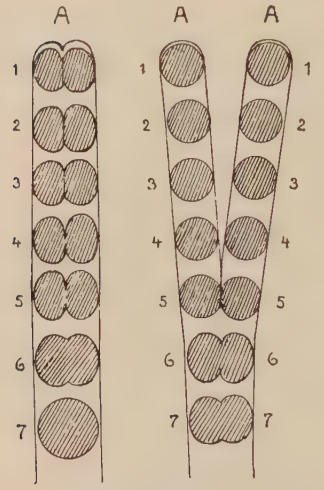
This albino skunk illustrates a mutation of the loss of color factors. (From the Journal of Heredity).

additions of extra chromosomes. This is a frequent cause among plants. Dr. A. F. Blakeslee of the Carnegie Institute has made observations on thousands of Jimson weeds which he breeds for the purpose and has been able to make the most remarkable creations by the different combinations of chromosomes, all based upon original mutations. Some plants are notorious for the large number of mutations they produce.

Sometimes the mutation of a single gene will affect several organs of the body often sufficiently to cause the death of the individual, in which case the mutation is lost. This is the case with the yellow mouse. When the pair of yellow producing genes combine, it completely wrecks the embryo so that it never develops even to birth, as we have seen.

A mind picture of the chromosomes should be kept so as to more easily understand the actual happenings. A glance at the diagram will help. This shows the way in which the chromosomes divide longitudinally.

If after the division has occurred, both of the new chromosomes which are the product of the one, pass into one cell, instead of one into each, this will make a great difference in



The division of the genes in the chromosomes A, preparatory to the division of the latter into the identical daughter chromosomes A, A. (From Coe)

the appearance of the individual thus created, provided that it does not kill it. It accounts for unequal numbers of chromosomes and the effects they cause.

If one gene in the germ plasm mutates it may linger along for generations and suddenly appear, but not until it has found a mate like itself. People ask the question a great many times, "Where did all of these variations in individuals originally come from?" The answer is, "from mutations."

If we obtained a family of inbred rats such as those illustrated on page 120 inbred to such an extent that every rat was the duplicate of every other, except for sex differences, could we expect that this family would forever remain just as it was when we obtained it, even though we never brought in any outside germ plasm? The chances are good that before long there would be differences among the family, perhaps slight and perhaps great. It might take hundreds of generations before a change occurred, and it might be but a short time.

It would not be correct to compare a breed of animals with such a family of rats, because there is always more variation in breeds, but essentially the principle is the same. When man took hold of the horse, it was not like the great draft

horses we have today, and it seems probable from the record of the rocks that no such animal ever lived upon the earth. No one brought in germ plasm to increase the size of the horse, for there was none to be obtained. What man did do

Let nature do the turning. This cocker spainel was born with a short tail. A mutation was undoubtedly the cause.

was to take advantage of mutations, these sudden changes which have arisen continually during all the generations of the past.

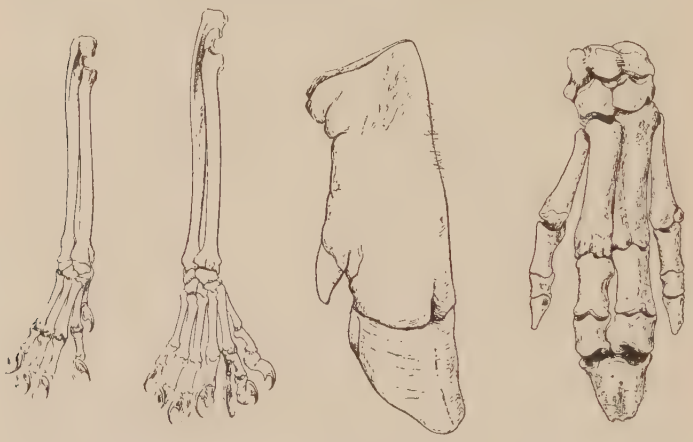
Heredity and environment interact and always have interacted and always will interact. A mutation without the help of environment would not go very far in changing a breed or species. If a mutation makes the animal unsuited to the environment it must either find a suitable one or perish.

Within the human family, however, this is less so than under natural conditions. Our tender-hearted charity prevents the selective power of enironment from getting in its work and we thus perpetuate the individual even though the defect

or change make him entirely out of harmony and everlastingly unhappy. In many cases he is actually encouraged to reproduce.

Nature is sometimes cruel (at least it seems so to us) but she is always kind. We try to be always kind, but much of our kindness is cruelty. Nature eliminates the defective whether the defect was caused by a mutation or by combinations of recessive genes, thus ending the unhappy family. Would that we could all have the true prospective so that we could help nature to do as she desires instead of hindering her. Misdirected charity is one of the curses of all civilized countries.

Thus mutations plus the selective influence of environment may tend upward or downward in the evolutionary scale. They may result in losses, like the bobtailedness of cats, the hornlessness of cattle, the silkiness of feathers in fowls, the



Skeleton of the forefoot of a normal cat and of a "doublepawed" mutation. A mutation caused the mulefoot hog. The hoofs of the two large toes fuse, but the bones remain separate except for the fusion of the terminal bones.

(From Coe)

loss of digits in the feet or hands, the loss of bones within the digits; or they may result in additions, like added numbers of digits so often seen in cats' feet, deeper coloration, longer tail, longer hair and the like. And these mutations may prove either recessive or dominant to the normal stock; no one can tell without trial.

The difference between a blonde Swede and a black African bushman is almost as great as the difference between the members of different breeds of horses. There has been a great change since the first man. That we must all admit. But it will be noticed that men have changed to conform to the environment in which they live. Let us study this a little, in detail; it has so great a bearing upon the means of selection of the breeds of domestic animals.

The first men must have been very similar in appearance. In order for them to change, a mutation must have taken place. Let us suppose that a great famine occurred among the animals that preyed upon human beings. Suppose that there were several hundred humans living out on a plain somewhere in Asia. In all probability the hungry animals routed the humans from their camp one day, and they fled for their lives, pursued by the beasts. Suppose there was one person in the group who had extra long legs, due to a mutation. He would run faster than the rest and perhaps escape from the beasts. He would go to another camp and take a wife and perhaps eventually his long legs would be seen cropping out in several hundred of his descendants in the next few generations.

And suppose another famine occurred among the beasts. All the men and women with the long legs might escape leaving the short legged ones behind to be devoured by the beasts. Thus a mutation would become a new racial trait.

Or assume that famine had driven a great tribe of humans on a long migration. They might have gone from a climate where very little pigment was needed in the skin, to a climate where the actinic rays of the sun were very intense. If there were a few with more pigment in their skin due to a mutation, they would be the ones we would expect to survive, other things being equal. Thus a darker race would become fixed.

Or let us imagine that we have a gulf in which are many catfish. The rivers pour into this gulf, which is a small part of the ocean. Now suppose that in the gulf there happen to be some newly hatched catfish that have mutated so that they can stand fresh water as well as salt. And suppose an earthquake throws up a parcel of land across the mouth of the gulf. The water from the rivers is going to continue to pour in, and eventually the gulf, which is now a lake, rises high enough to go over its dam. Of course the water will become fresh. What will happen to our catfish? The ones which require salt water for their medium of life, will die; the pair

which have mutated will live and perhaps reproduce and a new race be formed.

In some animals the brain is very small. In others it is larger. In proportion to size, man has the largest of all. Man can take thoughts and put them together and make other thoughts. He can reason. Some of the other animals can

The skull of a negro compared with that of a dog. Note the relative size of the two brain cases.

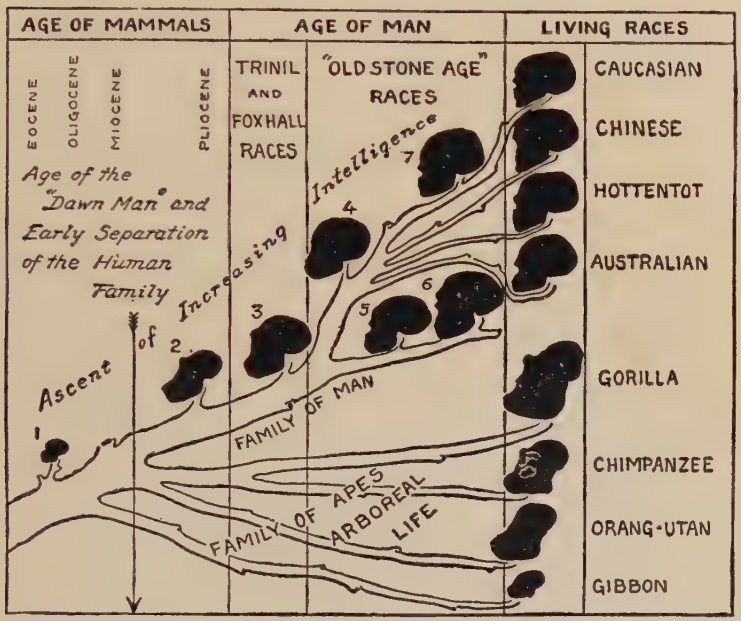
also reason after a fashion. But man reasons best because he has a peculiarly different development of the nervous system which enables him to do so. It is very likely that this brain developed slowly by the system of mutations.

The man who had the most development could think just a little better than his neighbor, and therefore he got the neighbor's wife, or perhaps he had the largest harem. Gradually this process has continued until the man who could think better than his neighbors was the man who had the most children, and those children inherited his ability to think. History gives us evidences of many rigid selections.

There is coal in the arctic regions. Coal was deposited by trees. So the artic must have once been a warm climate.

Perhaps there were once animals wandering about in what is now the land of snow and ice for the greater part of the year. Gradually as the earth cooled, the poles became colder while the heat persisted at the equator. The heat belt retreated slowly and what about the animals? If it were very hot, they must have been thin coated animals. Of course it took ages to occur, but suppose that we say it happened within a few centuries so that we may better comprehend the change.

As the climate became colder and colder, the coats of the animals needed to be thicker and thicker. If there were no mutations, it is obvious that the animals would have perished. But suppose that a few mutations did occur. Then these with



That mankind is not descended from the ape, but both man and the apes probably had a common ancestor, was Darwin's belief. (From Osborne)

the thicker coats would live to become parents of the next generation. And so the coats would be thicker and thicker.

By a survival of the fittest, accompanied by mutations which allowed the individuals to become fitter, the new races of men, plants, dogs, and what not, were developed by nature.

Likewise there has been a very great change among the races of animals under man's direction. Since the first there has been a tremendous change. And this has been brought about, as we have seen, by the selections of mutations which have cropped out from time to time, inbreeding these, until the new trait had become estblished, and thus through thousands of generations, man has created his breeds.

Mutations are therefore the basis of the great changes which have come over the various breeds and types of animals and plants, for the differentiation of the breeds themselves, for the present day evolution which is taking place all about us and our hope for improvement in the future. Deny the existence of present day evolution, and we might as well punch the time clock and call it a day for the race. There is then no hope.

But biology absolutely contradicts this belief. It shows that not only the animals are changing, but likewise man. Whither we are going no one knows, but if the eugenist has his way, it is toward a happier time than the present. No thoughtful person can deny change on every hand, and all thoughtful persons look for the day when men shall all have the well balanced temperaments and intellects, as well as sound bodies, that all of us so much admire today.

CHAPTER X

MUTIPLE MENDELIAN FACTORS AND THEIR PRACTICAL APPLICATION

With the facts of the two preceding chapters in mind let us return to our study of Mendelism. We have thus far considered traits which are governed by single genes. But most of the characteristics of the bodies of animals are determined by groups of genes working together. We must consider these.

Then again we must know how to predict the probable kind of offspring when there are differences in two or more separ-

Guinea pigs like those on the left when mated produce offspring like that in the center, which when mated to another like itself produces the four kinds on the right.

ate traits, each of which are determined by unit factors or genes. The more separate traits we consider at a time, the more complicated the prediction becomes.

As we have been talking about guinea pigs, and have seen the possibilities when we make certain color matings, let us consider what happens when we take two differing characters into consideration at once. Let us take colored or pigmented

fur and roughness of coat. We have seen that black is dominant over white. Rough coat is likewise dominant over smooth. So we shall mate a white, rough coated guinea pig with a black, smooth haired one. The progeny will be black and rough coated.

Now if we mate two of these let us see what we can expect. Let us make a checkerboard. First we must figure all the possible combinations of the genes in the sperm and ova. We shall call black, capital P (pigmented) and white, little p (non-pigmented); rough coat R and smooth coat r. In other words we have these traits all combined in each guinea pig: P,p,R,r. There are four combinations which they might make: PR, Pr, pR, pr. That is, each of the sexes might produce them.

It is very important to notice that these different types are produced in *equal numbers* and that each gets only one of each pair of genes. Otherwise the results would not follow. So the outside of the checkerboard shows the possibilities for the sperm on the top and for the ova along the side. When they unite, they might unite as shown in the squares:

	PR	Pr	pR	pr
PR	PR PR	Pr PR	pR PR	pr PR
Pr	PR Pr	Pr Pr	pR Pr	pr Pr
pR	PR pR	Pr pR	pR pR	pr pR
pr	PR pr	Pr pr	pR pr	pr pr

Germinal Formula	Appearance
PPRR, 1	1 PR)
PPRr, 11	2 PR)
PpRR, 11	2 PR) 9 PR
PpPr, 1111	4 PR) 3 Pr
PPrr, 1	1 Pr) 3 pR
Pprr 11	2 Pr) 1 pr
ppRR, 1	1 pR)
ppRr, 11	2 pR)
pprr, 1	1 pr)

There are sixteen possible combinations, but when we look these over and select the individuals by appearance, on the basis of dominant traits, which are represented by the squares we will find that there are only four types and these would be 9 PR or black, rough coated, 3 Pr, or black, smooth coated 3pR or white, rough coated, and 1 pr or white smooth coated. But of all the lot there would be only four that would be pure bred; namely, the PPRR, and the ppRR, PPrr, pprr. All the others would have unstable germplasm.

I once owned a little dog, named Jeff, that was a wire haired, tri-colored dog. Here is the breeding: His mother and father had been litter mates, their father had been a black and tan airedale, the mother a tri-colored beagle hound. Jeff's parents had both been black and tan, wirehaired dogs. His ears were considerably longer than his parents' but otherwise he was like them except for the color. Black and tan is dominant over tri-color, and wire hair over smooth hair.

If we work out Jeff's history on a checkerboard, we find, when we take the ova and sperm cells, that we might have (calling T, black-and-tan; t, tri-colored; R, rough coated; r, smooth coated): TR, Tr, tR, tr.

	TR	Tr	tR	tr
TR	TR TR	Tr TR	tR TR	tr TR
Tr	TR Tr	Tr Tr	tR Tr	tr Tr
tR	TR tR	tR Tr	tR tR √	tR tR √
tr	TR tr	Tr tr	tR tr √	tr tr

Jeff might have been any one of the dogs represented by the squares with the checks in them.

So we see that this is a very practical thing for the breeder to know or for the man to know who is interested in the development of new breeds, or for the person who is interested in the science of eugenics, or the improvement of the human race.

Let us now turn our attention to the case of several factors all working to determine the same end product. We shall first use color inheritance in the human as an illustration. In the guinea pig and several other animals, the black pigment is dominant over albinism, which is really absence of color.

In the case of the human, however, very few persons are totally devoid of color in the skin. The fairest Swede has

much color compared with the genuine albino which lacks it altogether.

On a visit to an institution for the feebleminded I saw several genuine albinos. It was a scorching summer's day and there they sat in the shade of a tree with their overcoat collars turned up about their necks as though they were cold. The perspiration stood out in beads all over their faces. I asked them why they kept the coat collars turned up, whereupon they told me to look at their necks, which I found were covered with blisters.

The poor unfortunates could never become toughened to the sun, because they were lacking the necessary pigment in the skin which is nature's protection. Contrast these with the Africans who have the greatest amount of pigment in the skin, for which reason they never sunburn.

Dr. Charles B. Davenport of the Carnegie Institution has made an intensive study of skin color and finds that in the white man there are two pairs of genes which he calls aa and bb. He finds that each of these exerts a different amount of influence and therefore he gives a, a value of 1, and b, a value of 2.

He also finds that the corresponding genes in the African are dominant over those of the white man, and he calls these AA with a value of 19 each, and BB with a value of 16 each. The white man has the genes aabb; the black man AABB. What happens when a white and black marry?

When the germ cells of the persons form they have AB and ab. So when they unite in the offspring, the child will have AaBb, for which reason it is a mulatto. Adding these together we find that there is half the total amount of pigment.

But what would be the possibilities when two mulattos marry? Well, let us see. In the germ cells of each there are A, a, B, b, genes. All of these cannot go into the sperm or the ova and so we must figure the chances. It is possible that any of the following combinations might occur, AB, Ab, aB, ab. Very well, then it is possible that a sperm containing any one of these combinations might meet with an ova containing any one of them or vice versa. The following checkerboard shows the expected outcome.

	AB	*Ab*	*aB*	*ab*
AB	*AB* *AB* 70	*Ab* *AB* 55	*aB* *AB* 53	*ab* *AB* 38
Ab	*AB* *Ab* 55	*Ab* *Ab* 40	*aB* *Ab* 38	*ab* *Ab* 23
aB	*AB* *aB* 53	*Ab* *aB* 38	*aB* *aB* 36	*ab* *aB* 21
ab	*AB* *ab* 38	*Ab* *ab* 23	*aB* *ab* 21	*ab* *ab* 6

There are chances that a pair of mulattoes might have children ranging in color from very black to white. In fact, they sometimes do. Frequently a pair of mulattoes have a child which is almost perfectly white. But we can see from their

Two mulattos may have children ranging from white to black. Note the various degrees of color exhibited in this family. The boy at the extreme left is very black; the baby will pass for white. (From Davenport)

germinal composition that if two of the *aabb* persons were to marry, they could never produce children any lighter than they were. The intermediate stages might produce varying shades of color in their children, however.

We often hear of a pair of white persons having a black child and the blame is laid to some remote ancestor. That, however, is not the true explanation. No two white persons have ever produced a black child. But we can see that it is possible for two dark persons to produce a white child.

Now let us go a step further and consider three different traits at a time. Suppose we take the same two in the guinea pig and longness and shortness of coat for the third trait. Short coat is dominant over long. As usual, we must first figure out the possible combinations of the sperm and ova. We shall call short S and long s. This time we mate a rough coated, short haired, colored animal with a smooth coated, long haired albino. Our ova and sperm might have any of the following combinations of genes: SPR, SPr, SpR, sPR, spR, Spr, sPr, or spr,—eight in all, in equal numbers. Let us make another checkerboard and figure again all the possibilities:

	RSP ↓	RsP ↓	RSp ↓	Rsp ↓	rSP ↓	rsP ↓	rSp ↓	rsp ↓
RSP→	RSP RSP	RsP RSP	RSp RSP	Rsp RSP	rSP RSP	rsP RSP	rSp RSP	rsp RSP
RsP→	RSP RsP	RsP RsP	RSp RsP	Rsp RsP	rSP RsP	rsP RsP	rSp RsP	rsp RsP
RSp→	RSP RSp	RsP RSp	RSp RSp	Rsp RSp	rSP RSp	rsP RSp	rSp RSp	rsp RSp
Rsp→	RSP Rsp	RsP Rsp	RSp Rsp	Rsp Rsp	rSP Rsp	rsP Rsp	rSp Rsp	rsp Rsp
rSP→	RSP rSP	RsP rSP	RSp rSP	Rsp rSP	rSP rSP	rsP rSP	rSp rSP	rsp rSP
rsP→	RSP rsP	RsP rsP	RSp rsP	Rsp rsP	rSP rsP	rsP rsP	rSp rsP	rsp rsP
rSp→	RSP rSp	RsP rSp	RSp rSp	Rsp rSp	rSP rSp	rsP rSp	rSp rSp	rsp rSp
rsp→	RSP rsp	RsP rsp	RSp rsp	Rsp rsp	rSP rsp	rsP rsp	rSp rsp	rsp rsp

So now, on the basis of appearance, judging from the dominant and recessive traits, we would have eight kinds of guinea pigs, divided as follows: 27 SPR, 9 Spr, 9 sPr, 9 SpR, 3 sPr, 3 Spr, 3 spR, 1 spr. Look over the list and you will see that there would be but eight animals which have uniform genes, and these would be SSppRR and sspprr, SSpprr, SSppRR, ssPPRR, ssppRR, SSpprr, sspprr. All of the rest would not have their genes evenly matched. But the guinea pig with the long hair, the white color, and the smooth coat would be the only one composed of all the three recessive pairs of genes.

Does this sound a bit theoretical? Do not conclude too hastily that it is not soundly practical.

When guinea pigs which are pure for traits in question, and which differ in three traits (P) mate, they will produce offspring possessing the three dominants (F1). When pairs of these (F1) offspring mate, they may produce offspring of eight sorts (F2). It will be seen that the traits of the grandparents have been reassorted in different combinations on the basis of chance.

Suppose, for example, that you wished to calculate the expected proportion of offspring from a given mating, you could quickly determine whether the mating would be worth while

providing that you knew the dominant and recessive Mendelian traits. You might determine that the chances of your being successful were too slim, and thus save time and money.

Anyone who has seen the great color variation in the grey in such dogs as the German shepherd, the husky, the Norwegian elkhound, will realize that they present a complex problem. Likewise the red fox which varies all the way from red, through the cross and silver shades to black.

Let us take human intelligence for another illustration. In general, when a feebleminded person marries one with good intelligence the children are of varing degrees, generally much brighter than the feebleminded parent.

Professor Hunt proposes that there are five pairs of genes which control the degrees of intellect. Indeed the idea looks extremely reasonable when one considers it. We shall omit the checkerboard which would be of great size and take only the summary. Here is the table,which, it must be remembered, is only the summary of a five factor checker board.

Classification of Grades of Intelligence on Five Factor Basis

Idiot	0 factors	Aabbccddee
Imbecile	1 factors	aabbccddee
Moron	2 factors	AAbbccddee
Average	3 factors	AABbccddee
	4 factors	AABBccddee
Low average	5 factors	AABBCcddee
	6 factors	AABBCCddee
High average	7 factors	AABBCCDdee
	8 factors	AABBCCDDee
Eminent	9 factors	AABBCCDDEe
Genius	10 factors	AABBCCDDEE

The idiot has a mind equivalent to that of the average child up to the age of two years; the imbicile has a mind similar to that of children of three to six inclusive; the moron has a mind similar to that of children from seven to twelve. The moron group is divided into 3 sections, low, medium, and high.

In all of the records of the Eugenics Record Office, or in the archives of any institution, you could not find one instance of two feeblemined persons, who themselves were children of feebleminded persons, having produced a normal child.

On this account perhaps it would be better to consider the above table to represent the grades of intelligence starting with the low-average person and going up to the potential genius. Professor Hunt's same figures, working in conjunction with a pair of determiners for feeblemindness, would then account plausibly for the degrees of feeblemindness, as well as the degrees of the normal condition.

From the foregoing it is apparent that the matter of predetermining traits which are governed by multiple genes, is not an easy one, especially when the individuals have a wide assortment of genes Indeed it is difficult to find animals or people who have homogeneous groups of genes. This fact makes for the variety in life It is the answer to many questions which perplex the person unacquainted with the basis of breeding. Why does the genius so seldom have children who are equally gifted? Why does a moron prostitute sometimes have a child who is reasonably intelligent? The answer to both of these questions is, first because every child has two parents, and second because of this heterogeneous assortment of genes.

Take any group of high grade people which has been determined on the basis of intelligence tests, suppose that they marry among themselves within the group, will they have children all of whom are equal to them in intellectual ability? Of course not, but by the same token they will have some children who will be higher in the scale than they themselves. Suppose a pair of low powered intellectuals produce a child which is considerably higher in the scale than they are, does that show there is nothing to heredity? On the contrary it proves the case. All one needs to do is to make an inquiry and one finds more of the same sort in the pedigree. By careful marriage continually within the same classes of intelligence, if we may speak of such a thing, the assortment of genes tends to become more and more homogeneous and the extraneous genes which make for change become lost.

Every breeder has owned animals which produced offspring much better or much worse than the parents. I have raised cattle which were much larger than their parents. Knowing the ancestry I bought a bloodhound that was so poor a specimen that although he was the only dog in his class in a show, the judge placed him third. I mated him to a bitch which was a mediocre specimen. Most of the pups were better than

either of the parents, and three were so much better that one could scarcely recognize the family resemblance. The same principle applies to mental traits because they are for the most part governed by multiple genes. Know as many of the ancestors as possible, get a mind picture of the traits under consideration, and within rough limits it is possible to predict the limits of the potentialities, upper or lower.

Beside these hereditary reasons for the production of offspring different from the parents, we must remember that the environment has a great deal to do with the ultimate use to which many traits are put, for that is often the only way in which we can judge the real worth. That is one of the causes for persons being rated by history as geniuses who in reality might have been very ordinary men but who were thrown into an environment which brought out their few sterling traits. Likewise we all know of many who like those who sleep in the semetary at Stoke Pogis, made immortal by Thomas Gray:

> Full many a gem of purest ray serene
> The dark unfathom'd caves of ocean bear:
> Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air.

So often one hears people say, "His father was a carpenter, here he is president of the railroad; that shows there is nothing to heredity." But now we see how they err. Furthermore many of the occupations which in our day seem to require so little skill, a generation ago required much. The trade of carpenter alone was of a very different nature than it is today. I know an old carpenter who built dozens of houses and never used an architectural plan other than one he drew roughly on a scrap of paper. He was a genius, but a carpenter.

CHAPTER XI

MENDELIAN TRAITS

It would take a shelf of books to describe all of the traits of domestic animals and their modes of inheritance. A great number of them are controlled by multiple genes, and thousands of others have never been determined. It is safe to say that only a very small proportion of the traits of most animals have been determined.

As an example of the enormity of the task of learning the units into which the many kinds of domestic animals may be separated, look at the head appendages of fowls on page 86. These types are all inherited by definite laws, but they are only the heads. Think of all the other traits for which the inheritance must be learned.

Not for years will enough of the traits of domestic animals and man be known to make a very great store of knowledge. However it is surprising how many we already know, certainly enough to be of inestimable help to every breeder. Of the many animals, the laboratory kinds have been best analyzed. They could be handled cheaply, or cheaper than the larger animals. The larger and more important the animal seems to be commercially, the less we know about it.

The fruit fly which can be bred by the thousands in bottles and fed on banana peelings has been so thoroughly analyzed that over two hundred characteristics are known about it, and as already mentioned the places of the various genes on the chromosomes have been determined quite accurately.

The best that can be done in the present chapter is to present a summary of the known traits in domestic animals and man. In many cases these may not be unit genes. It will be of great help, however, if we know what results when animals with differing characteristics mate. Then, too, we must remember that often a trait which is dominant when two breeds cross, is not dominant when others cross . Thus when we believe that a trait is dominant, we must know the breeds which have been used in the cross, in order that we may not be deceived.

Head appendages of fowls. (From the American Poultry Journal)

The following, therefore, are practically merely lists of the fragmentary knowledge of the present day, but enough to help in improving mankind and the races of our animals.

INHERITANCE IN MAN

HUMAN TRAITS WHICH HAVE BEEN SHOWN TO FOLLOW DEFINITE RULES OF INHERITANCE.

I.	Traits which Blend in the F1 Offspring	6
II.	Traits which show Dominance or Recessiveness to the Normal Condition in the F1 Offspring	68
III.	Sex-Linked Traits	17
IV.	Probably Mendelian, but Dominance Imperfect or Uncertain	16
V.	Clearly Hereditary, but Rules of Inheritance Uncertain	53
VI.	Associated Traits	5 pairs

I. Traits which Blend in the F1 Offspring.

1. General body size
2. Stature
3. Weight
4. Black skin color†
5. Hair-form (round vs. flat in cross section)†
6. Shape of head (round vs. long)†

It is possible for such traits to show segregation in subsequent generations, but it is probable that a majority of blending traits in man are polygenic in nature, behaving like the inheritance of skin-color in negro-white crosses.

II. Traits Showing Dominance of One Condition and Recessiveness of the Corresponding in the First (F1) Generation of Offspring, and Segregation in the Second (F2) and Subsequent Generations.

DOMINANT	RECESSIVE
1. Body size and shape	
(a) Achondroplasy	Normal size
(b) Normal size	True dwarfs (i. e. ateleiotic)
2. Skeleton	
(a) Brachydactyly (i. e. short digits and limbs)	Normal condition
(b) Absence of distal phalanges	Normal condition
(c) Polydactyly (i. e. extra digits)	Normal condition
(d) Syndactyly (i. e. fused webbed or reduced number of digits)	Normal condition
(e) Symphalangy (i. e. fused joints of digits, or orthodactyly)	Normal condition
(f) Exostoses (i. e. abnormal outgrowths of long bones)	Normal condition
(g) Osteopsathyrosis (i. e. fragility of bones)	Normal condition

DOMINANT	RECESSIVE
(h) Double-jointedness	Normal condition
(i) Radio-ulnar Synarthrosis	Normal condition
(j) Head form: Brachycephaly	Dolichocephaly
3. Countenance	
(a) Hapsburg lip	Normal
(b) Non-Jewish facial type	Jewish facial type
4. Skin	
(a) Pale thick skin	Colored thin skin
(b) Brunet complexion†	Intermediate and Blond
(c) Intermediate†	Blond complexion
(d) Normal pigmentation	Albinism
(e) Spotted white (Vitiligo)	Uniformly colored
(f) Tylosis palmae et plantea	Normal condition
(g) Epidermolysis (i. e. excessive formation of blisters)	Normal condition
(h) Congenital hypertrichosis	Normal condition
(i) Hypotrichosis (i. e. hairlessness, associated with lack of teeth)	Normal condition
(j) Immunity to Poison Ivy† (Rhus toxicodendron)	Susceptibility to Poison Ivy
(k) Ectodermal abnormalities (skin thickening, nail marking)	Normal condition
5. Hair	
A. Color	
(a) White forelock	Normal (i. e. solid color
(b) Dark brown	Light brown to "tow" and light reds
(c) Black	All other colors
(d) Canities (i. e. patchy graying of hair)	Normal (i. e. solid color)
B. Cross Section	
(a) Curly (i. e. flat in cross section)	Straight (i. e. round in cross section)
(b) Beaded (i. e. cross section not uniform, or "monilethrix")	Normal (i. e. uniform cross section)
(c) Digital hair	Absence
6. Eyes	
(a) Front of iris pigmented (i. e. brown or black eye)	Only back of iris pigmented(blue eye)
(b) Hereditary cataract	Normal condition
(c) Glaucoma (internal pressure and swelling of eye-ball)	Normal condition
(d) Ectopia lentis (displaced lens)	Normal condition
(e) Retinitis pigmentosa† (i. e. pigmentary degeneration of the retina)	Normal condition
(f) Congenital Aphakia	Normal condition
(g) Congenital Ptosis	Normal condition

DOMINANT	RECESSIVE
7. Ears	
(a) Normal condition	Deaf-mutism
(b) Normal condition	Otosclerosis
8. Intellectual capacity†	Very great ("genius")
(a) Average	
(b) Average	Very small (see also "Nervous System)
9. Temperament	
(a) Feebly-inhibited (Hyperkinetic)	Over-inhibited (Hypokinetic)
10. Special talents	
(a) Non-musical	Musical
(b) Non-artistic	Artistic
11. Right-handedness	Left-handedness (and ambidexterity†)
12. Nervous system	
(a) Huntington's Chorea	Normal condition
(b) Muscular atrophy (i. e. progressive neural muscular atrophy)	Normal condition
(c) Normal condition	Idiopathic epilepsy
(d) Normal condition	Constitutional feeble-mindedness
(e) Normal condition	Manic depressive insanity
(f) Normal condition	Dementia praecox
(g) Normal condition	Paranoia
(h) Normal condition	Involutional melancholia
(i) Normal condition	Alcoholism
(j) Normal condition	Hysteria
(k) Normal condition	Friedrich's ataxia
(l) Normal condition	Meniere's disease
(m) Normal condition	Sydenham's chorea (St. Vitus' dance)
(n) Normal condition	Thomson's disease (lack of muscular tone)
13. Kidneys	
(a) Diabetes insipidus	Normal condition
(b) Diabetes mellitus	Normal condition
(c) Normal condition	Alkaptonuria (urine dark after oxidation)
14. Respiratory System	
(a) Normal condition	Bronchial asthma
15. Palmaris Longus Muscle	Absence
16. Teeth	
(a) Lateral permanent incisors	Absence

III. Sex-Linked Traits.

These traits or qualities are "dominant in males and recessive in females."

1. Coloboma
2. Atrophy of optic nerve (neuritis optical)†
3. Myopia
4. Color blindness ("Daltonism," inability to distinguish red from green)
5. Night blindness (Inability to see by faint light)
6. Nystagmus
7. Ichthyosis (scaly skin)†
8. Pattern baldness
9. Multiple sclerosis (Differential degeneration of the nerve tissue)
10. Grower's muscular atrophy (dystrophia muscularis progressiva)
11. Hemophilia
12. Wanderlust
13. Deficiency in sense of smell†
14. Thalassophilia (sea-lust)
15. Toothlessness (toothless man of India)
16. Webbed toes
17. Microphthalmia

IV. Probably Mendelian, but Dominance Imperfect or Uncertain.

1. Defective hair and teeth
2. Extra teeth
3. Double set of permanent teeth
4. Harelip and cleft palate
5. Cryptorchism
6. Hypospadias
7. Twining trait (possibly recessive)
8. Dental agnesia (absence of certain teeth)
9. Bi-lobed ear
10. Dent in forehead (possibly dominant)
11. Human protein sensitization
12. Digital anarthrosis
13. Iso-agglutinins (as figured in blood-grouping)
14. Double crown of the scalp
15. Ankylosis (stiffening of joints)
16. Degeneracy of Cornea

V. Clearly Hereditary (i. e. Runs in Families), But Rule of Inheritance Uncertain.

1. Longevity
2. Handclasp
3. Diatheses to many specific diseases, as:—
   (a) Pneumonia
   (b) Cancer
   (c) Abdominal hernia
   (d) Inguinal hernia
4. Stuttering or stammering
5. Chlorosis
6. Epistaxis (nosebleed)
7. Telangiectasis
8. Splenic anemia with enlargement of the spleen (Gaucher's splenomegaly)
9. Gout
10. Goitre
11. Exophthalmic goitre (Graves' disease)
12. Literary Ability
13. Mathematical ability
14. Mechanical ability
15. Artistic Ability
16. Heart defect
17. Pernicious anaemia
18. Arteriosclerosis

(Continued)

V. Clearly Hereditary (Continued)

19. Jaundice (hereditary form, splenomegaly with acholuric jaundice)
20. Migraine
21. Rheumatism
22. Von Recklinghausen's disease (neurofibromatosis)
23. Scoliosis
24. Raynaud's disease
25. Angio-neurotic oedema (Quincke's disease)
26. Milroy's disease (persistent hereditary oedema of the legs)
27. Mongolian imbecility (possibly recessive)
28. Amaurotic family idocy
29. Megalophthalmus
30. Progressive Central Muscular Atrophy (infantile form, familial)
31. Hereditary spastic paraslegia
32. Marie's cerebellar hereditary ataxia
33. Paroxysmal familial paralysis
34. Hereditary tremor
35. Handwriting
36. Degeneration of macula lutea
37. Arthritis deformans
38. Spasmodic croup
39. Hereditary icterus
40. Angina pectoris
41. Cystinuria
42. General paralysis
43. Hay fever
44. Hypertrophic emphysema
45. Leprosy
46. Myxoedema
47. Neurasthenia
48. Obesity
49. Paramyoclonus multiplex
50. Periodical paralysis
51. Hereditary finger-print pattern
52. Memory
53. Astigmatism
54. Congenital Dislocation of Thigh-bone

VI. Associated Traits (Possibly Chromosome-Linkage).

ONE TRAIT	ASSOCIATED TRAITS
1. Brachydactylism	Shortness of stature
2. Osteopsathyrosis	Porcelain-blue color of sclera or "whites of eyes"
3. Hereditary nail defects	Hair defects
4. Night Blindness	Myopia Strabismus
5. Feeble-mindedness	Epilepsy

† Method of inheritance not agreed upon by all investigators.
* Castle, W. E. Genetics and Eugenics, 1926.
‡ E. R. O. Eugenics Record Office.
§ Publications of the Carnegie Institution of Washington.

INHERITANCE IN HORSES

Very little is known about the genetics of horses aside from the inheritance of color and even this has not been fully studied. Apparently there are several minor factors which

act on the intensity and distribution of color which have yet to be determined. Trotting is dominant over pacing. Some horses certainly do better over long distances than in the shorter runs, and this quality seems to be inherited but no one knows as yet just how. Many other traits have been observed but none is as yet sufficiently known to list.

Of the colors, the original is supposed to be like that of the so-called Prejvalski horse which is a native of the plains of Mongolia. In appearance it resembles an ordinary bay horse. It has a black mane, tail, and legs. The black and yellow are more in contrast, with the black above and shading off into yellowish color underneath. It is not beautiful to say the least, and doubtless the color has been discriminated against until horses with this color are seldom seen. Our present day bay horses are of a much brighter and deeper coloration.

Variations from this color have developed by mutations, such as black horses which have lost the factor for bay thus allowing the black to appear. Other solid colors appear to act as simple factors as appears in the table.

Spotted horses are especially interesting in that they resemble other animals genetically. The ponies which are seen at circuses, having black and white spots, are simply an extension of white over large areas. The extreme of this is the pure white horse with the colored eyes and nose. This should not be confused with the albino which has pink eyes, nor with the white horse which has turned white from age, but which was born black and turned gray and then white, as all gray horses do. There is also the most usual form of spotting which is simply the white feet or stockings and the blaze on the face.

Bay is dominant over black or chestnut or mahogany brown.

Black is dominant over chestnut but recessive to all other colors.

Chestnut is recessive to all other colors.

Sorrel is recessive to most other colors.

Gray is dominant over all colors except roan.

Roan is dominant over all other colors.

Trotting is dominant over pacing.

Dr. Sewall Wright has sought to name the genes which produce color by giving each a letter. The following is his list:

R — r roan vs. not roan
G — g gray vs. not gray

D — d dilute vs. intense pigmentation
A — a bay vs. black pattern
B — b black vs. chestnut coloration

Then he went further and calculated the probable interaction of these genes and thus adduced the following table:

Factors	gr	gR	Gr	GR
DAB	dun	dun roan	gray	gray (born roan)
DaB	mouse	mouse roan	gray	gray (born roan)
DAb	cream	cream roan	gray	gray (born roan)
Dab	cream	cream roan	gray	gray (born roan)
dAB	bay	bay roan	gray	gray (born roan)
daB	black	blue roan	gray	gray (born roan)
dAb	chestnut	strawberry roan	gray	gray (born roan)
dab	chestnut (liver?)	strawberry roan	gray	gray (born roan)

INHERITANCE IN CATTLE

Cattle have been studied more than horses, but much still remains to be learned. The following table is a summary of the traits of cattle gathered by Professor Victor A. Rice:

DOMINANT	RECESSIVE
High milk yield †	Low milk yield
Low fat percentage †	High fat percentage
Beef type in head and forequarters	Dairy type
Dairy type, in rear quarters	Beef type
Zebu, skeleton, dewlap	Native India cattle
Native India cattle:	Zebu
Skin color	
Size of horns	
Black	Red, dun, yellow, brown, fawn
White spotting, inguinal region	White spotting on face, throat, shoulders, rump, tail above switch, legs
Defective small teeth	Normal
Albino	Pigment
Ear notched	Ear normal
Ear double	Ear normal
Muzzle pigmented	Muzzle clear
Tongue pigmented	Tongue clear
Polled	Horned

† Not pure dominants.

Besides these Dr. W. E. Castle finds hornlessness (polled) to be dominant over the horned condition, and Dexter form (short legs) to be dominant over Kerry form (legs normal).

We have seen that Shorthorn cattle may have either white, red, or roan color. The roan color is believed to be an imperfect dominant of either the white over the red or the red over

the white, just as is the case with the Andulusian fowls. In this case the segregation in the F2 generation occurs in the expected Mendelian proportion of 25 per cent red, 50 per cent roan, 25 per cent white.

INHERITANCE IN SWINE

Dr. L. J. Lush of the Kansas Experiment Station published in the Journal of Heredity in 1921 the results of a four years' investigation in the inheritance of various traits in swine. Many crosses were made and the following summarizes his results and gives us the best record of traits which we have as yet :

Litter Size

Wild litter size of four, apparently dominant to larger litters.

Set of Ears

Erect ears dominant to lop ears by three principal and perhaps some modifying factors.

Shape of Face

Fairly long, narrow, straight (wild) apparently dominant over Tamworth type.

Long, narrow straight (wild) dominant over Berkshire type.

Shape of Face

Fairly long, narrow, straight (Tamworth) dominant over Berkshire type. Short dished face (Berkshire partially dominant over moderate length of dish of Duroc.

Colors. White

(This includes a summary of previous work in color inheritance.) Self-white dominant over all other colors (one factor). White belt usually dominant (two factors). Six white points are extremely diluted red. No albinism in swine.

Black

Self-black (English large black) dominant to Tamworth red; Hampshire black dominant to Duroc red (one factor); Berkshire, Poland China black when crossed with red breaks up into black spots on lighter background of red, sandy, or white. Single factor extended by modifying factors to cover all of body except six white points.

Red

Two kinds of self-reds. Tamworth red barely dominant over Berkshire black—strong restriction factors for black in Tamworth.

Duroc red when crossed with black allows more black spots to appear (as masked out at birth black contrasted with absence of black gives perfect 3:1 ratio in F2 and a close approximation to 1:1 in the backcross).

Duroc has two factors, absent in the Berkshires, both necessary for production of red.

Roaning

"Appears quite frequently among the descendants of self-whites by self-reds, or of self-whites by belted blacks. Often is not apparent at birth but develops later."

Wild color is dominant over not wild.

There is every indication that coat color is determined by a number of factors, but at present the best we can do is to understand the published results of experiments and observations. Gustav Frohlich reported in the Journal of Heredity for 1914 the following results from mating different breeds. This is summarized by Rice as follows:

I. White of Improved German Swine (Edelschwein) over:
   White and Black of Hanoverians.
   Black of Berkshires.
   Grayish black of European wild pigs.
   Grayish black of Cornwalls.
   Red of Tamworths.
   Black of Caucasian wild pigs.

II. Grayish black of European wild pigs over:
   Red of Tamworth.

III. Black and white of Hamshires over:
   Red of Tamworth.

It is commonly known that the mule foot is dominant over the normal condition.

INHERITANCE IN SHEEP

Not much is known about the unit traits of sheep. The most intensive study yet made appears to be that of Davenport and Ritzman of the inheritance of wool characters. Certain things are known which are of importance. The following brief list is all that are known to behave as unit characters:

White color is dominant over black.

Earlessness is dominant over short eared condition.

Long eared sheep when mated with earless sheep produce an intermediate condition—short eared.

Two short eared sheep produce all three kinds.

Blackness of wool (in Karakul sheep) at birth dominant over white condition.

Curly wool of Karakul dominant over straight wool.

Dense wool of Karakul dominant over long wool.

Lustrous wool of Karakul dominant over dull wool.

Black face dominant over Gromet pattern (black marks over eyes; black ears with gray margins).

White face dominant over Gromet pattern.

Hornlessness is dominant over the horned condition in females.

The horned condition is dominant over hornlessness in males.

Dr. Alexander Graham Bell purchased a flock of sheep and studied the inheritance of the number of nipples, but no definite rule was worked out before his death. He brought into the herd some sheep with six nipples and by a process of selection he finally bred a flock with a larger average number of nipples than those with which he began. In 1890 his lambs born averaged 2.27 nipples; those born in 1913 averaged 5.40.

INHERITANCE IN DOGS

Among the first persons to publish results of studies in the inheritance of dogs were Dr. C. C. Little who investigated the records in the American Kennel Club of Great Danes, and Pointers, and Dr. J. Mc I. Phillips who studied color in Cocker Spaniels.

As far as I can learn I was the first person to study inheritance in dogs by the actual keeping of dogs and making specific matings with the object in view of determining specific Mendelian traits I began this work in 1920 when I tried to learn the inheritance of the trait of baying on the track or trailing silently.

First let us review the work of Dr. Little on pointer dogs which was published in 1914. After recording the results of many matings, he deduced the fact that color in pointers was not the result of a single trait but the interaction of several. He gave the gene for black pigment the letter B and its equivalent absence b. The gene for the extension of liver and black pigment in the hair he called E. "In the presence of this factor the animals have brown or black pigment on a white ground; in its absence the colored spots on the coat are yellow of various shades."

Thus there are four kinds of colors in pointers with the following genetic compositions: 1, BE- -black; 2, bE—liver; 3, Be—yellow with black nose; 4, be, yellow with brown nose.

From this I deduce the following: A black may be any of the following genetical compositions: BBEE, BbEE, BbEe.

A liver may be: bbEE or bbEe.

A yellow with black nose may be BBee or Bbee.

A yellow with a brown nose must be only bbee.

By making any combination of these factors it is easy to predict the outcome of any mating and it is easy to calculate the germinal composition of the parents judging from their

color and from their past offspring. Thus a black with the composition BBEE when mated to any other color would produce nothing but black pups.

Doctors Barrow and Phillips derived their data from private records. They accept the designation of Doctor Little and have presented the following chart or table. This is given just as it was published in the journal of Heredity. This table is valuable for color determination of pointers, setters and other kinds of spaniels, also crosses between these.

	Zygotes	Gametes	Class 1 BLACK	Class 2 BLACK	Class 3 BLACK	Class 4 BLACK	Class 5 LIVER	Class 6 LIVER	Class 7 RED	Class 8 RED	Class 9 YELLOW OR LEMON
Zygotes			BE BE	BE Be	BE bE	BE be	bE bE	be bE	Be Be	Be be	be be
Gametes			BE BE	BE Be	BE bE	Be / BE be / BE	bE bE	be bE	Be Be	Be be	be be
Class 1 BLACK	BE	BE	B	B	B	B	B	B	B	B	B
	BE	BE									
Class 2 BLACK	BE	BE		3B		3B		3B	1B	1B	1B
	Be	Be		1R	B	1R	B	1R	1R	1R	1R
Class 3 BLACK	BE	BE			3B	3B	1B	1B	B	3B	1B
	bE	bE			1L	1L	1L	1L		1L	1L
Class 4 BLACK	BE	Be / bE				9B 3R	1B	3B 1R	1B	3B 3R	1B 1R
	be	be				3L 1Y	1L	3L 1Y	1R	1L 1Y	1L 1Y
Class 5 LIVER	bE	bE					L	L	B	1B	L
	bE	bE								1L	
Class 6 LIVER	be	be						3L	1B	1B 1R	1L
	bE	bE						1Y	1R	1L 1Y	1Y
Class 7 RED	Be	Be							R	R	R
	Be	Be									
Class 8 RED	Be	be								3R	1R
	Be	be								1Y	1Y
Class 9 YELLOW OR LEMON	be	be									Y
	be	be									

BREEDING COCKER SPANIELS BY ALGEBRA

To use table, first determine the class to which each dog belongs, and then trace the columns to the square in which they meet. Here the colors to be expected and their average relative numbers will be found. A single large letter in the square indicates that the entire litter will be of that color. B=black, R=red, L=liver or chocolate, and Y=lemon. The class to which a given dog belongs can in some cases be determined by a careful analysis of the pedigree and its color, in others by the results of a previous mating. Or the procedure may be reversed. To determine the class of any animal examine a litter the result of mating with another animal, preferably of another color. The determination of the class of two black parents is the most difficult and several other matings may be necessary before an accurate determination is made.

But besides this analysis of colors in cocker spaniels, they have deduced other data which are very valuable.

Spaniels frequently have a dilution factor in their germplasms which when combined with black produces dilute black

or blue; when combined with red, produces cream; when combined with yellow produces a color which appears white, but which is actually a dilute yellow and can be photographed, so that it is easy to determine its presence.

The dilution factor is recessive to the lack of dilution.

Roan color is dominant over lack of roan.

Spotting is dominant over the solid colors, but it is likely that spotting is caused by multiple factors, which in their most perfect condition act as a single unit.

Bi-color (known in other breeds as black and tan) is recessive.

Solid colored dogs showing white spots on breast and toes may be classed as solid colors.

In 1919 Drs. C. C. Little and E. E. Jones published a paper on the inheritance of coat colors in Great Danes. They investigated the records of the American Kennel Club and from this study we can deduce the following conclusions:

There is a single gene's difference between the intense colors (black, brindle, and fawn) and the dilute varieties (dilute black, dilute brindle, and dilute fawn). They designate the intensity gene as D and the dilution gene d.

The three coat colors, solid black, brindle, and fawn are dependent on three complementary factors, E, for full extension of the pigment, E1, for its partial extension as seen in the brindling pattern, and e1 for its restriction to the muzzle, nose, feet and a small area near the eyes, a condition typical of the fawns. Black (E) animals may carry either brindle (E1) or fawn (e1) but not both; brindles (E1) may carry fawn (e1) but not black; fawn may carry neither brindle nor black.

Harlequin differs from solid coat color by a single gene.

Minute white spots on the chest or on the feet occur rarely among progeny of solid colored dogs. Their appearance is probably due to a factor (s) for piebald spotting. (S) is the designation given to solid color.

It should be remembered that this study was made on Great Danes, based upon studies previously reported in this section on dogs, but without doubt the same facts apply to many other breeds including the bull dogs, greyhounds, and others.

Dachshunds have been studied and it was found that black was dominant over brindle, yellow or red, but in certain cases the red sometimes dominated black and tan. Possibly this was caused by the red in question being a different genetic color.

Little and Jones have summarized the known Mendelian traits which have been studied and have given them letters as designations as follows:

C is the color factor
c1 is a modification of it and produces partial albinism.
B is black pigmentation.
b1 is a modifier and produces orange or lemon yellow coat color.
E is extension of black or brown pigment.
e1 is the modifier producing fawn color.
D is intensity of coat color.
d is dilution of coat color.
H is irregular white spotting (harlequin).
h is the modification of H, producing in the absence for any other factors for spotting, a solid coat.
S is solid coat color.
s is for slight amount of white as spot on chest or foot.

It is also stated that R is a roaning pattern which may be dominant over the lack of it, and that black and tan is probably recessive to solid color.

My own study of the coat color in hounds makes me feel differently about several of the above connotations. The principal colors of hounds are tan, black and tan, white and black and tan, and all variations of the several colors; namely, solid white or black or tan, tan and white and black and white. Besides these hounds often have dilute colors and a ticking factor which Wright has called Roan, (R). I have deduced the following:

Black and tan is dominant over tri-color.
Solid tan is dominant over black and tan.
Solid tan is dominant over tri-color.
Black-and-tan dominant over another genetic tan or bronze color.

The ticking is a simple dominant. A solid colored dog may carry the ticking factor, which does not show due to the absence of the white coat.

I believe it will be most clearly understood if the coat colors of hounds are thought of as coats of cloth. There is first a white put over the whole body. On top of this is laid a tan. The tan is not always sufficient to cover the white and leaves a little showing on the chest and the tips of toes and tip of tail, but this is a different white from the other which comes later. On top of the tan is spread a black saddle. On top of the black saddle is spread another white which may have holes in it. Beside the above tan is another which is inherited as a recessive.

Sometimes this white will have no holes in it and will cover all the colors underneath. Wherever the white has holes in it the under colors will show. Now this white may be made very imperfect by a ticking gene in which case it will be pierced by tiny windows as it were. On the legs the windows will let the red color show through while on the back the black of the saddle will show.

The same principal holds true for Dalmations which have much larger spots than the ticking which hounds and bird dogs exhibit. The Dalmatian spots are also inherited as a dominant.

The following list contains the dominant and recessive traits which I have worked out by breeding dogs for the purpose, or by observing dogs which were mated by friends for me, or by the observations of matings between different breeds when I was assured of the authenticity of the mating:

Instincts and Mental Traits. Note: All breeds of dogs have all of the instincts possessed by the rest in some degree. The inheritance of these special aptitudes and instincts is based upon long selection to develop special traits for special purposes, and without the dependence which we can put on heredity, there would be no breeds such as we have, especially those which are almost distinct on the basis of special inherited aptitudes. Because of the fact that dogs show all gradations of these traits, there is no such thing as dominance or recessiveness of them; rather it is modification. But the change brought about by mixture of breeds is so great in many instances that it is equivalent to a modified dominance and recessiveness.

Dominant	Recessive	Breeds used
Trail barking	Still trailing	Hounds x many others
Normal	Pointing	Pointer x bull
Normal	Herding	Collie x bull
Fearlessness	Normal	Airedale x hound
Normal	Shyness	Shepherd x pointer
Normal	Reserved	Shepherd x bloodhound
Normal	Animated	Airedale x fox terrier
Normal	Slashing fighter	Hound x elkhound
Bull grip	Normal	English bull x hound
Natural trailing	Normal	Bloodhound x elkhound
Ground scenting	Air scenting	Hound x pointer
Head Normal	Head Long	Bloodhound x elkhound
Normal	Stub nose	French bull x St. Bernard
Normal	Broad head	Shepherd x bull dog
Normal	Narrow head	Airedale x fox terrier
Lop ears	Erect ears	St. Bernard x French bull
Turned at tip	Bat ears	Fox terrier x shepherd
Tight skin	Great wrinkle	Bloodhound x foxhound
Normal voice	Drawl of hound	Airedale x bloodhound

Note: Each grade of ear length is progressively dominant over the next longer grade. Ear length among the extremes is governed by multiple factors.

Normal	Cleft palate	Spaniels, bulldogs
Dewclaw	Absence of dewclaw	Shepherd x Elkhound
Hair characteristics:		
Coarse hair	Fine	Airedale x setter
Normal	Fine	Hound x spaniel
Wavy hair	Straight	Airedale x hound
Short hair	Long hair	Bull x St. Bernard
Short	Intermediate	Fox terrier x Spitz
Normal	Undercoat	Hound x elkhound
Normal	Thick coat	Elkhound x collie
Normal	Medium thick	St. Bernard x bull
Tail Characteristics:		
Chow type	Normal	Chow x Airedale
Normal	Huskie	Hound x elkhound
Stub tail	Long	in Eng. Sheepdogs
Droop tail	Erect carriage	Shepherd x hound
Straight	Screw	St. Bernard x French bull
Straight	Kinky	Pit bull x hound
Long kinky	Short screw	Pit bull x bull terrier
Leg length:		
Normal	Long	Elkhound x hound
Bench curved	Normal	Basset x beagle

Coat colors: (excepting those already mentioned)

Sable and white	Tri-colored	Hound x collie
Sable and white	Brindle	St. Bernard x French Bull
Fawn	Tri-color	Hound x bull
Brindle	Tri-color	Hound x bull
Black and white	White	Fox terrier x spitz
Gray	White	Shepherd x Samoyed
Tan	White	Hound x Bull terrier
Black	Sable and white	Newfoundland x St. Bernard
Black	Black and white	Among Newfoundlands
Black	White	Newfoundland x white collie
Black	Brindle	Spaniel x bull
Gray	White	Shepherd x Pomeranian
Gray	Yellow and white	Shepherd x Setter
Gray	Tan	Shepherd x hound
Black guard Hairs	Absence	Elkhound x collie

Note: It should not be interpreted that the results indicated in this table were derived entirely from the breeds shown in the column at the right. In some cases the same result would be obtained by mating many others. As an example take the case of dewclaws.

I could show several dozen matings which prove their inheritance in a typical Mendelian fashion, both among the pure breeds and in matings between individuals of different breeds.

Size: Without doubt this is caused by a large number of multiple factors. One curious fact deserves especial mention, namely that the size of the mother seems to exert a tremendous effect upon the pups ultimate size when breeds of extreme size are crossed. A small fox terrier male when bred to a sixty pound Airedale female produced pups averaging around fifty pounds in weight. A St. Bernard, crossed with a French Bull produced pups which averaged but little larger than the mother. I have noticed this tendency repeatedly. Whether the reduced or increased size due to the mother's influence is inherited would make an extremely interesting problem for study.

INHERITANCE IN CATS

The determination of the genetics of cats is most difficult if one tries to learn anything from records of litters. On account of the disposition of cats which is well known, it is frequently almost impossible to know the sire of a litter of kittens. For this reason cat genetics is more or less unreliable as so frequently observers have based their conclusions upon what they believed was fact whereas later experiments have proved them to be incorrect. Hence the short list of traits which follows. This was compiled by Dr. W. E. Castle.

Unit-Characters of Cats

Dominant	Recessive
1. Tabby.	Not tabby (black or blue).
2. Black.	Blue.
2a. Normal (intense) pigmentation.	Siamese dilution.
3. Short hair.	Long hair (angora).
4. Colored all over.	Spotted with white.
5. White (eyes only colored).	Colored all over.
6. Yellow.	Not yellow (tabby or black).
7. Tailless (Manx).	Long tailed.
8. Polydactyl.	Toes normal

It is commonly believed that white cats with blue eyes are always deaf. Certainly some are but apparently not all. Tailless cats although included in the table are not always dominant over the normals. Occasionally long tails appear, but whether this is caused by lack of exact knowledge about the true parents, is another question. It is also commonly believed that tortoise shell colored cats are only of the female sex.

INHERITANCE IN MICE

To look at an ordinary house mouse, one would not suspect that their color, agouti, was governed by so many genes in the germplasm. Geneticists write the formula of the pure house mouse like this: AA BB CC DD PP SS yy . Many genes have been carefully worked out so that it is now known just what the interactions between these will produce. The capital letter usually stands for the dominant and the small letter for the recessive corresponding trait. Thus:

A—development of agouti, gray, or gizzled pattern.
a—the non agouti pattern.
B—black
b—brown or chocolate
C—color determiner.
c—lack of color or albinic determiner.
D—fully pigmented.
d—dilute
P—normal dark eyed, pigmented.
p—pink eyed, non pigmented.
S—solid, or self colored.
s—piebald.
Y—yellow.
y—non-yellow.

The interactions of these genes produces the colors shown below with their genetic formulas: (on the basis of appearance)

CABDPS—Wild type agouti
CABDPs—Spotted agouti
CABDpS—Pink eyed agouti
CABDps—Pink eyed spotted agouti
CABdPS—Dilute agouti
CABdPs—Spotted dilute agouti
CABdpS—Pink eyed dilute agouti
CABdps—Pink eyed spotted dilute agouti

CaBDPS—Black
CaBDPs—Spotted black
CaBDpS—Pink eyed black
CaBDps—Pink eyed spotted black
CaBdPS—Dilute black
CaBdPs—Spotted dilute black.
CaBdpS—Pink eyed dilute black.
CaBdps—Pink eyed spotted dilute black.

CAbDPS—Cinnamon
CAbDPs—Spotted cinnamon
CAbDpS—Pink eyed cinnamon
CAbDps—Pink eyed spotted cinnamon
CAbdPS—Dilute cinnamon
CAbdPs—Spotted dilute cinnamon
CAbdpS—Pink eyed dilute cinnamon
CAbdps—Pink eyed spotted dilute cinnamon

CabDPS—Brown
CabDPs—Spotted brown
CabDpS—Pink eyed brown
CabDps—Pink eyed spotted brown.
CabdPS—Dilute brown.
CabdPs—Spotted dilute brown.
CabdpS—Pink eyed dilute brown.
Cabdps—Pink eyed spotted dilute brown.

c with any other genes—albino

(After Sinnott & Dunn)

Remember that each of the above genes has a partner. In the case of the dominant genes the partner may be either dominant or recessive but the combination will produce only a dominant trait, of course. Where a recessive (small letter) is shown it must of course have a recessive for a partner. Thus if the mouse were a spotted dilute agouti it might have a formula as follows: Cc AaBb dd Pp ss, or CC AA BB dd PP ss. But in either case on the basis of appearance (dominant traits) it would be C A B d P s.

INHERITANCE IN RODENTS

The mouse, rat, guinea pig, and rabbit, while in a sense not as commercially important as the domestic farm animals, yet they deserve a space in our list of unit traits. We have seen the great number of color factors which have been learned from the mouse. The following list is one compiled by Dr. W. E. Castle. It will be seen how thorough has been the study of these animals. Beside these genes which are designated by letters, there are many others known which modify color patterns, as well as determine the pattern itself.

Some Unit-Characters of Rodents

Name of Factor	Symbol, Dominant Phase	Appearance of Dominant Individual	Symbol, Recessive Phase	Appearance or Recessive Individual
Color	C	Colored	c	Albino
Extension	E	Black or Brown	e	Yellow
Agouti	A	Gray (agouti)	a	Black (non-agouti)
Black	B	Black or black agouti.	b	Brown or brown agouti
White spotting	S	Self colored	s	Spotted with white
Dark eye	D	Dark eyes and coat	d	Pink eyes and coat pale where not yellow
Intensity	I	All pigments dark	i	All pigments pale
Hair length	L	Short-haired	l	Hair long and silky
Rough coat	R	Coat rosetted	r	Coat smooth
Rough modifier	M	Coat slightly rosetted	m	Coat rosettes fully developed
Vienna white	V	Coat and eyes colored	v	Coat white, eyes colored

INHERITANCE IN POULTRY

Dr. W. E. Castle has deduced from the literature on poultry the following list of dominant and recessive factors. Besides the characters given in this list there are many others which appear to be imperfectly dominant or recessive such as the possession of a crest or topknot; and there are many which are produced by multiple traits. The following abstraction contains those traits which have been most carefully studied.

Unit-Characters of Domestic Fowls	
A. Sex-linked	
Dominant	**Recessive**
1. Black skin (silkies)	Normal skin (dominant in females, imperfectly recessive in males).
2. Silver (lacing, spangling, penciling).	Gold (lacing, spangling, penciling).
3. Striped down of chicks, black breast of adult male (game bantams).	Plain down, brown breast of male.
4. Barred feathers.	Unbarred feathers.
4a. Spangling (lacing, penciling).	Non-spangled, etc., feathers.
B. Not Sex-linked	
5. Black plumage.	Yellow (or buff or red plumage. (Hybrid often like jungle fowl.)
6. White of white Leghorns.	Colored.
7. Colored.	White (of Silkies).
8. Colored.	White (of rose-comb bantams).
9. Colored.	White (of white rocks).
10. Normal feathers	Silky feathers.
11. Frizzled feathers.	Plain feathers.
12. Crest.	No crest.
13. Extra toe.	No extra toe.
14. Yellow skin.	White skin.
15. Rumpless.	Normal tail.
16. Walnut comb.	Rose, pea, or single comb.
17. Pea comb.	Single comb.
18. Rose comb.	Single comb.
19. Single comb.	Combless (Breda).

INHERITANCE IN PIGEONS

Dr. Dewey G. Steele of Yale University has compiled for us the following information relative to inheritance in pigeons. Doctor Steele has experimented extensively with these birds and has taken the greatest pains to give only such information as is in his estimation thoroughly demonstrated by experimental methods. One might find many other Mendelian factors or genes listed in the literature about pigeons but those which follow are thoroughly proven, and any uncertain ones have been purposely omitted.

The *primary colors* of the older naturalists are the best known color types in pigeons. The genetic relationship of these types have been studied quite fully by Dr. L. J. Cole of the University of Wisconsin. These *primary colors* are: black,

dun, blue, silver, red, yellow and white. Chemical studies have shown that all of the first four named colors are due to modifications of black pigmentation, and that red and yellow are due to a red pigment in different amounts. White is due to complete lack of any pigment. In addition to the basic colors mentioned above a new series has recently been recognized which is due to a third pigment known as chocolate or brown. Many of these brown types have been confused by the breeder with the dilute modifications of black. The following chart illustrates the *primary colors* as well as the new chocolate brown series. An *intense* bird has about three times as much pigment as a *dilute*, and these differences are given in the chart under the column headed "Amount".

In order to better understand the term *arrangement* it will be necessary to note some of the essential features of feather structure.

Few people realize what a feather really is. Actually it is composed of the hardened cell walls with the living elements dried up. There are no nerves or blood vessels in an old feather.

The little branches which run from the shaft are known as barbs. Still smaller branches known as barbules run off in a corresponding manner from the barbs. The microscope reveals that these little barbules are tiny rods, one cell in thickness. By *spreading* is meant the more or less uniform distribution of the pigment graules thruout the cells of the barbules. By *clumping* is meant the pigment granules are confined to a more or less central location in the old cells.

BASIC COLORS

Pigment	Amount	Arrangement	Color of Bird
Black	Intense	Spread	Black
	Intense	Clumped	Blue (black bars)
	Dilute	Spread	Dun *
	Dilute	Clumped	Dun barred Silver 1
Chocolate	Intense	Spread	Chocolate *
or	Intense	Clumped	Brown barred silver 1
Brown	Dilute	Spread	Drab
	Dilute	Clumped	Drab barred silver
Red	Intense	Spread	Red uniform over entire
	Intense	Clumped	bird
	Dilute	Spread	Yellow uniform over entire
	Dilute	Clumped	bird
No pigment present	Not an **"Albino"** type		White

* Dun and chocolate are frequently confussed by the breeder.
1 Dun barred silver and brown barred silver also are confused.

When the black pigment granules are *spread* the bird appears black or dun depending upon the amount of pigment; the clumped arrangement of black pigment combined with the peculiar light relations due to feather structure gives the feather a slate blue or silver appearance, depending in a correspondent way upon the amount of pigment.

The *clumping* factor acts upon black and chocolate but for some unknown reason does not affect ordinary red.

Various degrees of spreading and clumping on black were studied by Dr. Sarah VanHoosen Jones. She found evidence for an epistatic series with *dominance* in the order listed.

Black
Black blue-tail
Black checker
Sooty blue
Ordinary blue
Blue barless.

Cole and Kelley studied a dominant sex-linked factor which inhibits the development of black pigmentation. Its action on chocolate has not been studied thus far. It has no affect on ordinary red. When this factor is added to black the bird becomes a brick red with gray tail which is seen so commonly in homers. On blue check the bird becomes red check. Its general action is illustrated below. This is the A gene.

Black + A — Brick Red; gray tips of wings, rump and tail,
Black check + A — Red Check; gray tips of wings, rump and tail,
Blue (black wing bars) + A — Red Bar; gray tips of wings, rump and tail,
Dun + A — Yellow; Gray tips of wings, rump and tail,
Dun check + A — Yellow Check; gray tips of wings, rump and tail,
Dun barred Silver + A — Yellow Bar; gray tips of wings, rump and tail,

The "ash color" or gray sometimes seen in homers, carriers and certain other varieties is due to a further inhibition of brick red.

There are a large number of other factors which may modify all of these *basic* colors. Some of these are : white spotting, grizzling, lacing, etc.

Certain other characters have also been studied such as leg feathering, reversal of feathers—known as a frill, presence or absence of uropygial (oil) gland, number of tail feathers, eye color, silkiness or lace, etc.

A partial list of characters studied thus far is given in the accompanying table.

A partial list of factors in pigeons.

Dominant	Recessive	Notes
Black	Chocolate	Sex-linked
		Sex-linked
Intense	Dilute	
Extension of black or brown	Non-extension of black or brown (red or yellow)	
Grizzling	Solid color	Shows more strongly on clumped than on spread pigmentation.
		Sex-linked
A—factor	non-A types	
Spread	Clumping	
Baldhead white	Self color	
Normal	Frill	
Normal	Lace or silky	Sex-linked
Uropygial Gland present	Absence	Data very limited

INHERITANCE IN CORN

In the Journal, Genetica, Dr. E. W. Lindstrom has published a list of the traits of maize which have been determined by numerous investigators. This list is reproduced below. Dr. Lindstrom has also denoted the symbols which are generally used to classify the many traits. It will be seen that the list is long and that much is known about the genetic factors of this important food plant. The capital letters denote dominant traits while the small letters show that the trait is recessive.

ALPHABETICAL LIST OF GENETIC FACTORS IN MAIZE

A—anthocyan. General plant color found in aleurone, pericarp, stem, leaves, etc.
ab—abortive grains. No endosperm.
ad—adherent. Leaves and tassel adhering.
an—anther ear. Semi-dwarf plant with anthers thruout ear.
B—"brown". A plant color factor.
br—brachytic. Dwarf plant.
bh—blotched aleurone.
bl—blotched leaf.
bv—brevis. Dwarf plant.
C—colored aleurone, complementary to A and R factors.
co—coherent. Branches of tassel cohering.
cr.—crinkly leaf.
d—dwarf plant with anthers thruout ear.
de—defective. Partial development of endosperm.
dt—dotted leaf. Circular spots of light green.

f—fine-striped leaf.
fi—fine-streaked leaf.
fl—floury-flinty endosperm.
g—golden leaf.
gl—glossy leaf.
gs—green-striped leaf.
I—inhibitor of aleurone color.
in—intensifier of red and purple aleurone.
j—japonica-striped leaf.
l—luteus (yellow) seedling. Factor for xanthophyll and carotin pigments.
lg—liguleless leaf.
li—lineate leaf.
mr—midrib. Leaf consists of but little more than midrib.
ms—male sterile. Anthers produce no pollen.
na—nana. Dwarf plant.
nk—naked. Cob and tassel almost free from spikelets.
P—pericary and cob color. An allelomorphic series Prr, Pwr, etc.
Pl—Purple plant color. Develops in local darkness.
Pr—purple aleurone. Red aleurone—pr.
R—"red" aleurone. One of the complementary factors (ACR) for aleurone color, and also in an allelomorphic series affecting plant colors and pericarp: Rr, Rg, rr, rg, rch, etc.
ra—ramosa ear.
rs—spotted aleurone.
sc—scarred endososperm.
sh—shrunken endosperm.
sl—slashed. Slashed or shredded seedling.
sm—salmon silks.
sp—spear. Spear-like seedling. Usually lethal.
su—sugary endosperm.
te—tassel ear e) Two types producing only pistillate flowers
ts—tassel seed e) in the tassel.
Tu—tunicate ear (pod corn).
v—virescent seedling. (Complementary factors v1 and v2).
w—white seedling. (Complementary factors w1 and w2).
ws—white sheath.
wx—waxy endosperm.
Y—yellow endosperm. Duplicate factors known.
ys—yellow-striped leaf.
zb—zebra-transversely striped leaves.
zg—zigzag stalk; duplicate factor with z.

CHAPTER XII

PURE LINES AND VARIATIONS

It is very important to be able to distinguish between a mutation and a variation. The latter is just what the name implies. No doubt the same genes and the same number of genes determine the length of the ears in a Boston terrier. There is a vast difference between the ear length of the Boston terrier and the bloodhound.

There are probably several pairs of genes which account for the difference in length here. If a Boston should give rise to a pup with ears considerably longer, we might logically suppose that it had been caused by a mutation.

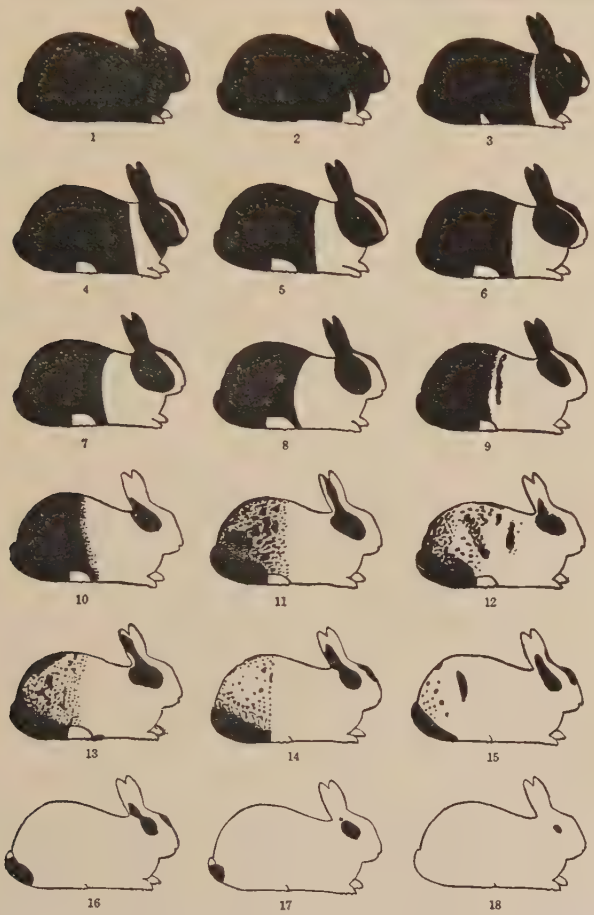
But if we took measurements of the length of all the ears of 1,000 Boston terriers and compensated them with the size of the dogs we would find that there was quite a difference between the longest and the shortest. If we mated the longest to the shortest we would have ear lengths running from the shortest to the longest. The length would not be like either one or the other. They would vary within the extremes of the trait. But suppose we mated the Boston with a dog having ears which were longer by just one gene's difference. Then we would have ears which were like one or the other.

Professor Castle of Harvard has shown the color pattern of Dutch rabbits and the variations within that pattern. In this case there is a definite determiner of the pattern of which Figure 9 is the average. The rabbit's color varies one way or the other from this median. In his laboratory he has raised rabbits with all these degrees of color.

There must be, therefore, other genes which modify the pattern gene so that they determine the amounts of black or white. Thus we see that variations are caused by genes which affect the amount of color. Professor Castle has also discovered that the pattern of the hooded rats is determined by a gene.

It is apparent that there must be modifying genes to change the color. In the case of skunks, we know of the pattern, but there are variations of it ranging all the way from the star skunk which is almost completely black, except for the

white spot on his head, down through all degrees of color to the skunk which is almost entirely white. There are therefore a *group* of genes concerned in the production of color.



The great variation in color in Dutch rabbits. The pattern is determined by one gene which works in conjuinction with modifying genes to produce the variety. (From Castle)

Now that we are acquainted with the multiple gene basis for heredity let us look at the experiment with dogs on Page 61 and consider only the ear length. The grandparents are a bloodhound and an elkhound. Notice that the bloodhound

has very long ears, that the elkhound has fairly short ears. Now notice that the offspring has ears which are intermediate in length. I mated the female with her brother from the same litter. Let us adopt for convenience one of the abbrevia-

Variation in the color pattern of hooded rats. (From Castle)

tions of science. The parents we shall call, P, their offspring are the first family generation so we shall call them, family generation number 1, or F1. Therefore I mated two F1 dogs together. Their progeny were the second family generation or F2.

Notice the ear length of the F2 pups. They were seven weeks old at the time the pictures were taken. Notice that there are all degrees of ear length, with two having quite long ears, and two like the mother and one with somewhat shorter ears.

Just how many factors there are governing ear length in dogs, I do not know but there must be several. In general there are four classes of ear length. The bloodhound stands at one extreme, the chow at the other. The fox hounds and bird dogs are in another class, and the airedales, dalmations, St. Bernards, Doberman pinschers, etc., have an ear length varying about a shorter standard.

It is obvious therefore that for a breed of dogs to be stable and breed true, they must have within their germ plasm the same genes uniformly. We are considering only ear length as an illustration.

If they were like the mongrel mother in the illustration they would be producing offspring with all sorts of ear length, and they would certainly not be a breed.

Supposing that we select the chow as an example of a breed that has the same number of genes for ear length, we would find a variation among those genes. To us the chow would be a pure breed of dogs.

PURE LINES

Having chosen a pure breed of dogs we would find that within it were groups we may call pure lines. To the biologist the term pure line means "all the progeny from a single self fertilized individual." This definition, of course, does not apply to animals but it seems to me that the term pure line

Variation in the color pattern of skunks. (From Castle)

adequately covers the condition I am about to describe fully as well as it does "the progeny of a self fertilized individual," which practically limits us to the vegetable kingdom.

If we selected all the chows with an ear length of two inches and mated them for many years we would be able to segregate from them certain families which always produced pups with ears about two inches long.

In like manner we could find families which vary around a standard of one and one-half inches. Now, no matter how much we bred within the two inch family we could not get pups with one and one-half inch ears. We would finally isolate a strain or pure line of dogs that might have ears varying twenty-four to sixteen eights of an inch, another varying from twenty to twelve, another varying from sixteen to ten, another from fourteen to eight. The general average of all of these families would be about sixteen. But the extremes would be eight and twenty-four. The members of the fourteen to eight strain would never give rise to offspring with shorter ears than eight nor longer than fourteen. In this way families of dogs are selected.

Dr. Raymond Pearl worked out lines of hens on the basis of their egg laying capacity. He had some families which

were very poor layers and within that family he could not get a hen to lay any more eggs than the limit for her family. He had others which would lay very large quantities, but would not go under a figure which was very high. These were pure lines or pure strains of hens.

The pure line is one which we must keep in mind if we are to improve our breeds. As soon as we bring inferior lines into the stock's germ plasm, it takes generations to remove the traces from the descendants.

One of the most variable breeds of dogs, regarding ear length, is the foxhound. Of these there are several distinct strains. There is the southern strain which I believe to be a mixture of bloodhound and foxhound because they give rise to pups with such varying degrees of ear length, and there is the Walker strain, the English, the American and several others. Each of these is a family by itself and there is quite some difference in the ear length. Each is a resonably pure family. The Walker is noted for the production of a medium short ear, and the pups are very uniform. The same is true of the English. They each tend, nevertheless, to vary about a standard.

It is interesting to watch the development of certain of the newer breeds. The Airedale, for instance, gives rise to pups of various ear lengths. The great average is about the same, but occasionally they produce pups with very short ears or fairly long ears. This simply shows that in the germ plasm of some members of this breed there still reside factors for longer or shorter ears, thus telling us that the breed was originally derived from a long eared and a short eared breed, probably the foxhound or the otter hound, as well as from a shorter eared breed like the wolfhound or deerhound.

Some day, after years more of selection, and elimination from the breed of sires which ever give rise to pups with longer ears, or shorter than the desired length, the Airedale will become relatively pure for the desired ear length.

Selection within a pure line is almost useless. We are handicapped by a limit. On the other hand these limits are very useful, because once we have arrived at our desired standard, we can be reasonably certain that the breed will stay within the narrow limits of the pure line. If we desire to improve the limits outside of a pure line, we must do so by

taking advantage of a mutation which is not very apt to occur, or by bringing new germ plasm into our strain, thus upsetting other things, perhaps, as well as taking our desired trait in the direction we want it to go.

SEX LINKAGE

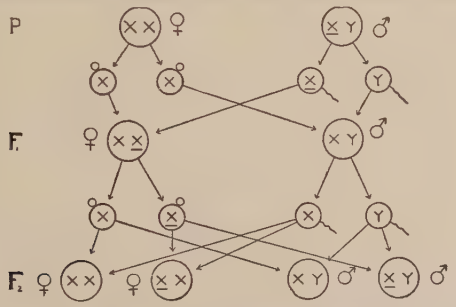
There is usually a great difference in appearance between the male and female of any species of animals. The male is generally larger and more powerful and possesses certain mental differences from the female. For the most part this difference is caused by the glands and their secretions, but back of the glands is another cause—the sex chromosomes.

A pullet which has had her ovaries removed will grow to look like a rooster. The caponized rooster grows to look like a hen. We all know the difference between the horse and the stallion, between the bull and ox. The boar grows tusks—the castrated boar does not.

But there are other differences which are not caused by any glandular effects. The former are known as sex-limited, the latter as sex-linked.

In the human family color blindness, or lacking the ability to distinguish red from green, is seldom possessed by a woman. Haemaphilia ("bleeding") also is a trait which is seldom inherited by women. This condition is brought about by a lack of clotting power in the blood, which causes the victim, when cut in any way, to bleed for many days. In the fruit fly there are more than thirty traits which are inherited by the male but seldom by the female.

The reasons for sex-linkage are easily understood. The traits which are sex-linked must lie on the certain chromosomes



which determine the sex. The reason they do not appear in the female is that they are dominated by the corresponding

chromosome of the female, but when they are transmitted to another offspring, they may unite with the Y chromosome,

Crosses of horned father and polled mother or vice versa produce horns in the male offspring; matings between hornless sheep produce hornless females and may produce horned males; hornless males cannot reproduce horns. Thus the inheritance of horns in sheep is as follows—dominant in males, recessive in females—typical sex linkage. (From Ritzman)

thus forming a male and the Y chromosome will lack the power to dominate it. Then the sex-linked traits reappear.

The diagram shows what happens. Occasionally, but very rarely, a female will receive two of the X chromosomes, and in this case she will exhibit it. Sex linkage shows us conclusively that the genes for certain traits lie on the sex chromosomes, and substantiate the chromosome and gene theory.

CHARACTER ASSOCIATIONS

It is known that the genes which determine some traits lie close together on the same chromosome so that they seem to nearly always stick together and produce the same effects. Let us take dogs as an example. It is reasonably safe to say that the longer are a dog's ears, the better is his scenting ability. In other words, the group of genes which cause the great development within the dog's nose which give him his scenting ability, also creates the length in the ears. The bloodhound, with his great earage, has unquestionably the keenest scenting abilities of any breed of dogs. The dogs with small ears seem to have less than the usual amount of scenting ability.

I have investigated many Airedales which were said to possess good scenting abilities and they have uniformly had considerably longer ears than the usual run of Airedales. It is the general concensus of opinion among hunters that the longer a hound's ears are, the better are his scenting abilities. When a group of dogs with varying ear lengths are hunted in a pack, and a very faint track is crossed, it is almost always the dog with the longest ears which finds it first.

I tried an experiment of dragging a bag of old meat, and letting dogs with different ear lengths hunt for it. This experiment covered nearly a month in all. The meat was dragged in a different place each day and removed a considerable distance so that the dogs could not "wind" it. Then all of the dogs would be tried, one after the other, in each case letting them try their best to locate the trail. At the end, the dog would be given a small piece of meat.

An Airedale and a German shepherd were the first to drop out, their time being one and one-half hours. Next came a mongrel with ears slightly longer than an Airedale's. Then a mongrel cross of a shepherd with a Gordon setter. Then a Walker foxhound, followed by a long eared southern foxhound, and lastly a bloodhound only eight months old which was able to carry the track eight hours after it had been made.

I do not claim that these dogs were representative of their breeds. They may not have been, but the fact is that they dropped out in proportion to the length of their ears. This may come as a shock to the persons who have heard about the

scenting prowess of the German shepherd, alias German police. In a test by the Hamburg Police Department of Germany, they were proved to have very mediocre scenting ability. The bloodhound has never been equalled despite the claims of publicity and advertising agents of the many breeds.

But there are exceptions to this association of characters. Sometimes these traits are not linked up together, but have been separated. Some of the lap dogs have extremely long ears and very short noses with poor scenting abilities.

It will be a most worth while experiment to devise tests for scenting ability and to determine the various native abilities of the several breeds, and then to correlate this with other traits. It must be done with many representatives of any breed before one can say with certainty what the qualities are. No one animal can speak for the whole breed he represents.

CHAPTER XIII

INBREEDING: UNMASKING DEFECTS

In the broad sense of the word, inbreeding means mating within a family. In another sense it means the purification of the stock. If we mate brother with sister, parent with offspring, uncle with niece, first cousin with first cousin, we are inbreeding. Anything further removed than first cousins we shall not consider inbreeding.

Taking the latter meaning of the word—the purification of the stock—and appreciating the full meaning of it, we see that inbreeding is not just what most of us have previously considered it to be. Inbreeding is the great means at the disposal of the breeder to originate new breeds or purify old.

We have already seen that brother and sister are more closely related than parent and offspring. In order to fully comprehend the idea which is at the basis of inbreeding, let us think of the genes and the fact that they are always in pairs. Is it not plain, then, that inbreeding tends to make the pairs of genes uniform?

Before we can intelligently answer the question, "is imbreeding desirable?", we must know the characteristics which are in the germ plasm. If he has reason to believe that there are genes which make for defects, surely the man who breeds animals for a business should not want to double these genes and make the offspring pure for a defective trait. He had better keep his progeny impure so that there will be a chance for the progeny to give rise to both good and bad, and then he can select the good. But the man who has at heart the genuine improvement of the breed, will see the question from a different angle. Some of the classic examples of inbreeding shed much light on the question.

When Dr. Helen Dean King of Philadelphia began inbreeding white rats, she selected a pair that were large, vigorous, rapid-growing, and prolific. These she mated. From the offspring she selected a pair which seemed to be in keeping with her idea of what an ideal white rat should be. She mated them. Again she selected and continued the improvement, breeding brother to sister for seven generations by which time she had apparently secured a uniform assortment of genes.

So she continued mating brother to sister until now they have gone through sixty generations.

In the past any breeder might shudder to think of mating brother to sister once. But if we select for excellent traits

Dr. Helen Dean King, inbred these rats. The parents are the fifty-ninth generation and the tiny ones the sixtieth generation of brother to sister mating. They are excellent virile specimens.

and discard the weaklings, I see no reason why we can not secure strains which are not only pure for the traits in question, but which will suffer no harm from inbreeding.

If Dr. King had not been careful about the characters which she selected she would have lost her rats in a few generations because the defective traits would have overcome the good and they might have become sterile and died out.

Dr. Charles B. Davenport has inbred mice for fifty and more generations. After less than half of this number had been produced he might almost have said that every mouse was the twin of every other, so identical were they. The reason is that they inherit the same assortment of genes in uniform pairs, and there are no longer genes left which produce defective characteristics.

Dr. Castle has inbred rabbits for many generations without harmful effects when the rabbits were selected for desirable traits as the inbreeding continued.

Take the Laverack strain of setters for instance. They were originated by breeding brother to sister for five generations, and Mr. Laverack selected the best from each litter and tested them for hunting ability as he inbred them. Thus only the best were selected and used. He must have approached making the strain very nearly uniform in their genes.

Dr. Boz and Dr. Weismann found that when they inbred rats for many generations they would diminish in fertility.

Their experiments were made many years ago when little was known about feeding and it is possible that the fertility was diminished by the lack of the reproductive vitamine, or possibly it was due to some effect of inbreeding. However, it is not likely that such extremes will be used in the breeding of domestic animals.

We have seen that a pure line limits the development of a breed or family. Inbreeding tends to make pure lines and when they are established it is useless to try to improve beyond their limits. So without doubt there will always be sufficient outbreeding to make up for the lack of fertility, if there is any.

We must admit that this practice has shown from practical results that it does diminish fertility sometimes to the point of total infertility. On this account it must be used very judiciously where animals have but one or two offspring per pregnancy.

In the case of the horse, the cow, and the sheep, for instance, if used as strenuously as in the case of animals like the hog, the dog, the rabbit, the fox, or the chicken, the results might prove disastrous because diminishing fertility could easily result in infertility and thus the line would be stamped out entirely. It is much safer to practice moderate inbreeding with such animals. In the same breath we must admit that on that very account, these animals are not as susceptible to rapid improvement by selective influences as are the animals which normally produce litters.

The great role of inbreeding should be the elimination of undesirable traits and the doubling up of desirable ones. If young from inbred animals are so weak that they cannot survive, they show beyond a doubt that within the germ plasm of the parents there are genes which, when combined, actually kill the offspring. Therefore, is it not highly desirable to rid the breed of them?

I prefer to think of inbreeding as an eliminative process rather than as a strengthening process. The yellow mouse is a healthy, virile individual while the pure yellow mouse is a weak thing that dies before it can be born. If there were any genes in the germ cells of an animal which produced such an effect, it would surely be desirable to eliminate them forever, and that is what inbreeding would tend to do.

When we think of inbreeding we usually think of cousin marriages among humans which have proved unfortunate. Now, as a matter of fact, while cousin marriages may not always be recommended, it is doubtful if they are as disastrous as is commonly supposed.

When such an idea once becomes prevalent every instance which tends to show that it is right is magnified greatly and the other side of the question is forgotten. But no one knows whether there is actually much more disaster from cousin marriages than there is from ordinary marriages. Some of the greatest figures of history have been the children of cousins.

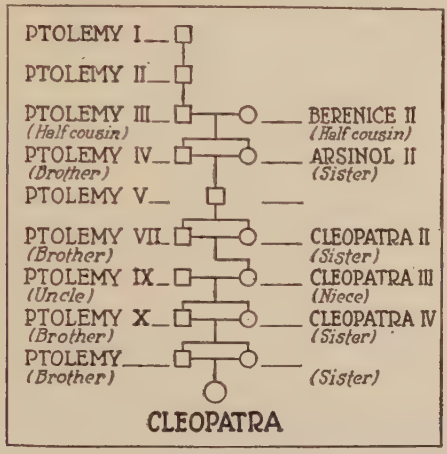
There are generally so many undesirable traits in every pedigree that are never made known that this accounts for the trouble. Eugenists are constantly advocating that people drag out the skeletons and rattle them for all they are worth so that the children may understand the undesirable traits in their families, and when they choose a mate, choose one who has none of these same traits. When two cousins marry and there is insanity in the family, the chances are good that there will be an insane child born from these normal parents.

If there were no skeletons hidden away in the closet and locked up so that no one might know of their presence, there is no reason why cousin marriages would be undesirable. But when there are skeletons, it is just as undesirable as it would be for the person to marry another from an outside family with the same skeletons. In other words, when there is a skeleton in a family it is very likely to be inherited by both of the cousins. We cannot and would not kill the children which do not come up to our expectations, as we can the defective animals, so there is a great difference in the two questions.

With animals it is desirable to learn where the bad traits are and breed them out, but with human beings to use stock farm methods is socially a bad practice. The Spartans developed a physically powerful race by this method, but it will probably never be done again, surely not while people "have a heart." In fact, with the present day knowledge of heredity there is no need for the use of so heartless a method.

Human beings are not susceptible to experimentation to any such degree as are our animals but very fortunately they have been kind enough to do some unconscious experimenting on their own account in the past, and such records are available.

Indeed, historical records of human inbreeding reveal a mass of facts. Here, for instance, is the family history of the famous Cleopatra:



History tells us that Cleopatra was intelligent and good to look upon. Her morals, would have to be judged by the standards of her own generation. Apparently so much inbreeding was not disastrous to the Ptolemy family.

In another Egyptian dynasty we find that brother and sister married for thirteen consecutive generations. It is reported that every member of the family were geniuses, and they continued so until there came a generation with only boys and there was no sister to marry. Only when there was need of finding a mate outside of the family did the genius disappear.

For a further example take the case of the Jews. We who are used to reading the Bible in a take-it-for-granted way, without benefiting by many of the greatest underlying lessons, have not noticed that it is one of the finest eugenics books ever written. It is crammed with eugenic lessons. Jesus taught by use of many eugenic parables, like the man who sowed good seed in his field.

Does not the Bible seek to trace the ancestry of Jesus back to Abraham and to give us the male line of descent without a break? Go a little deeper and we find that beside the male lines of descent, there was also a female line which traced directly to Abraham. And the amount of inbreeding, (I say

it in all reverence) was far closer than many breeders would think of using on a pure breed.

The method employed unconsciously, to originate the Jewish race is very close to the method which was used by breeders to originate new breeds of animals. The pronounced Jewish characteristics were established by inbreeding, and we may not account for them in any other way. Since the old system ended, the Jews have become segregated, keeping within their race in marriage extremely closely. Today when an orthodox Jew marries outside of his or her religion the relatives have a funeral service, for to them the person is dead. They burn all of the belongings, put the ashes in a coffin, and bury the person in effigy. Thus they tend to maintain their characteristics.

The custom of the marriage of brother to sister has become taboo. For years incest was the subject of Greek plays, but today we do not deign to mention the subject in polite society. Cousin marriage was also frowned upon. The Greeks at one time had laws inflicting the death penalty upon a man who married his cousin. Some states of the Union have laws preventing it—just why, I am sure they do not know.

These human results mentioned are cases of inbreeding where a majority of sterling traits ran in the families. There are cases of human families such as the degenerate families of the Jukes, Kallikaks, Nams, Hill Folk, W— family of Kentucky, etc., in which inbreeding and illicit relations occurred so that none are sure which is the parent of which child. Marriage records show the most ghastly results from such mating.

The records of the Psychopathic Laboratory of the Chicago Municipal Court of the family history of criminals show cases of inbreeding among inferior stocks which have resulted in the lowest type of criminals.

In the case of the Jukes, (a ficticious name) Max's two sons and five sisters of another family, with whom they consorted, gave birth to the beginning of the degenerate Jukes family. That family has over 600 descendants representing all stages of inbreeding and up to 1915 they had cost the State of New York officially over $2,000,000. No matter in what kind of an environment they have lived they have always been more or less shiftless and worthless.

What would we do to our animals if they were as worthless as this disreputable clan? But the State of New York where they live, refuses to pass a law allowing their kind to be sterilized when as a matter of fact they do not want children anyway, and the only reason they have them is because they cannot prevent it.

Animal breeders can learn a lot from the students of human heredity and they can also tell the average layman "a few things" about the improvement of the human family, judging from their observations from stock. We keep pedigrees of our animals and some of us see the good common sense of keeping pedigrees of our families.

We have learned from experience that to put our family on record in the Eugenics Record Office at Cold Spring Harbor, N. Y. is the best way we can insure the perpetuation of

The Eugenics Record Office, Cold Spring Harbor, Long Island, where human pedigrees may be filed.

the finest types in our family's future. It is surprising how many animal fanciers have filed their own family histories in this confidential repository.

PRACTICAL ASPECTS OF INBREEDING

Now to get back to the practical aspects of inbreeding, we must realize that dominant qualities are not affected by inbreeding. If we want them we can see to it that they are there and keep them by inbreeding. If we do not, we can select until they have not appeared in an individual, and breed from that individual.

Once a dominant character has gone, it is gone. But a recessive may linger along in the germ plasm for generations and then suddenly reappear. For instance, I wrote a short article which appeared in a widely read dog journal. I stated that when a dog with long hair mates with a short haired one, the short hair is dominant. I had many replies from breeders relating their experiences and asking advice.

There were no less than six persons who told me that they had mated a setter with a pointer, and that half of the pups had been born with long hair and that they were typical setters, and half with short. There were two who said they had mated a pair of registered pointers and some pups were born with long hair. How could I explain that?

If I were to tell the setter lovers that the setters were developed from the pointers, they might rise up in arms. On the other hand, if I told the pointer lovers that the pointer was a development of the setter, they too might be perturbed.

Now, there is no other explanation to my mind than these two: Either there have been a lot of pointers which are the offspring of a setter-pointer cross, registered as pointers, (and that would be dishonesty), or else the pointer was developed from a long haired ancestor and the long-hair-producing genes have come down through many generations as recessives, only to crop out when a pair happened to combine, and then the pair of recessive genes would produce the long hair. Inbreeding of any suspicious strain of pointers would bring this trait to light.

For a moment let us consider one of the great epoch making experiments on the subject of inbreeding. Dr. Donald B. Jones decided that if he could inbreed corn plants until he had bred out all of the defects, that he could then mate two such treated strains, and that the resulting offspring ought to possess tremendous vigor. So, for nine generations he inbred the corn.

With corn he could take the pollen from a plant and use it to fertilize the silks, or he could plant all the seeds from one cob in a row and mix the pollen among these plants. He made this experiment, and year by year the corn plants became smaller until they were so much inbred that they retained only the best traits, and were vigorous, pure specimens, although not as large as the original plants.

Finally, he crossed the ninth generation of each of the inbred strains. He planted seed which he had saved from all the years, and the resulting plants were the finest thing in

Hybrid vigor produced by mating the two inbred strains at the left. Continued inbreeding gradually reduced the size and yield of the plants, to that of the inbred ancestors. The comparative yields are shown in lower part of picture.

corn plants that New England had ever seen. The yield was tremendously increased as the illustrations show. In the case of corn the occasional outcrossing certainly developed added vigor.

Dr. W. E. Castle of Harvard inbred rats for seventeen generations and then mated two strains of inbred individuals. He says, "When two of these inbred races are crossed with each other, even though they had their origin in a small

common stock, many generations earlier, an immediate and striking increase of vigor and fecundity occurs."

This is more easily done in the case of rats and corn than in the case of other animals, but is is very possible that such an experiment, which would cover many years, would result in a greatly improved strain.

The following table shows the probable rapidity with which the inbred animals of a breed approach a condition in which all of the genes are paired uniformly, or in other words, each having a partner like itself. The data were collected and calculations made by Dr. H. S. Jennings and Professor H. D. Fish at the Johns Hopkins University.

Generations of Inbreeding	Brother-sister Matings	Generations of Inbreeding	Brother-sister Matings
1	50.00	12	94.31
2	50.00	13	95.40
3	62.50	13	96.28
4	68.75	15	96.99
5	75.00	16	97.56
6	79.69	17	98.03
7	83.59	18	98.40
8	86.72	19	98.71
1	89.26	20	98.96
10	91.31	21	99.15
11	92.97	25	99.64

It will be seen that *inbreeding does not create weakness,* rather it brings weaknesses which are already present, to light, where they may be eliminated. It might be expected that the breeds of animals which have been bred true for many generations, when crossed would produce increased vigor, but I can say that in my experience I have never seen such result. The reason for it is, I believe, that the breeds have such a great diversity of traits which are different from each other, that the vigor has no chance to manifest itself. What one part may increase another will cut down.

Furthermore, the breeds are not as much inbred as one might think. But that is very different from an experiment within the same breed of two inbred strains. I believe that with the breeds of almost all animals, crossing them does not make for increased productivity or vigor, despite a few outstanding exceptions.

The results of inbreeding depend to some extent on the previous history of the animal or plant used. If the animal

has been normally somewhat inbred (as with most laboratory animals) close inbreeding is not so likely to lower vigor as it is in normally outbred organisms such as horses, cattle, poultry, dogs, or vegetables where undesirable recessive traits have been kept masked by outbreeding.

Inbreeding is a real art, one which demands a high degree of courage. Not every man wants to face the facts. Altogether too many people would prefer to have an animal which appears to be a splendid individual on the surface, but which is likely to pass on undesirable traits, than to have one which may not be so good to look at, but will never pass on germ plasm which will create another less desirable specimen than itself.

An inbred individual which is also a good type of animal itself is the truly great sire or dam, and the prize winner which is untested is not to be compared with him or her in genuine value to the breed. So here again we see that the truly great breeder is not the man who goes about buying show specimens, but rather the man who inbreeds and tests and tries his animals until he knows the characteristics of their germ plasm, and who then knows how to combine this with the germ plasm of others to produce the desired ideal type.

WHAT IS A BREED?

We have been talking about breeds, but just what is a breed of animals? We cannot say that a breed is a group of animals possessing uniform pairs of the same genes because there are a great many differences within a breed. Take the setter dogs, for instance. In all the necessary respects for which they are useful they are alike. But consider the great differences in their colors. There are solid reds, blacks and tans, almost solid whites, black and whites, liver and whites, lemon and whites, setters with ticking which shows and with ticking which does not show. No, that is not the definition of a breed.

Neither can we say that all the dogs which have been developed for a certain purpose are a breed. Because, while the offspring from a mixture of these breeds will probably be useful for the purpose for which we need them, we would still have a great variety of appearances among the offspring.

An *ideal breed* then is a group of animals of the same species having uniform pairs of genes which determine certain desirable traits which have been agreed upon by those interested in producing the breed, as essential. *Practically,* a breed represents a standard of conformation, behavior, etc., which has been recognized and become reasonably uniform.

On the basis of this definition of an ideal breed, animals which in appearance might fill the requirements exactly, but which might have within their germ plasm, genes foreign to the breed, would actually not belong to the breed. The reason for this is that the genes would not be evenly paired. I have produced mongrels which would pass for Irish terriers. I raised a dog which even a judge said was an excellent type of Airedale, but this dog, when mated to a foxhound produced pups some of which looked like good foxhounds, whereas if the dog had been a pure Airedale, the pups would have all been wire haired.

Of all the domesticated animals, dogs, which have been closer to man longer than any other, show the greatest divergence among the members of the various breeds. This should be corrected, but if it were, many fanciers would want to group the off type individuals by themselves and give them a new breed name.

There are at present seventy-nine breeds recognized by the American Kennel Club, which is a far greater number than those of any other animal. Pigeons come second. There is much leeway allowed in the breeds of poultry, but even with them it is not comparable to the breeds of dogs. We shall deal with this further in the next chapter.

On the basis of this definition of an ideal breed we may classify the old fashioned short headed collie with the long headed collie, as one breed, although they are very different in head formation. We can classify the wire haired and the smooth coated breeds of dogs together, their only difference being in the hair coat and variations in color. We can group the long eared and the short eared foxhounds together. The breeds of setters and pointers are distinct on the basis of hair length, rather than on the basis of usefulness. They are both useful for the same purposes.

If we accept that definition, we shall come to see that breeding is more interesting and more easily understood, than if we have no common basis for understanding.

For example, let us take the Yorkshire hog. He must have uniform genes for hair length, for erect ears, for solid white color, several pair for the size, for the leg length, for the head shape, etc. Now, if an individual's genes were all uniform except one pair, and that, let us say, was altered by having one gene for black or spotting and one for solid white, even though the hog were solid color, he would not be pure.

He must have only white producing genes; those only are permissable since they have been agreed upon by the lovers of the breed, but if he had a recessive determiner for black, he would not be permissable, and he would therefore not be a pure bred individual, although he might be excellent in all other respects.

CHAPTER XIV

PREPOTENCY

What is a prepotent animal? The great originator of the Morgan horse family, Justin Morgan, has always been described as a very prepotent sire. Some of the great dogs that have sired large numbers of pups which have carried their stamp, and dogs that have originated great families, are described as prepotent.

Scientists are getting away from the term prepotency because they know so well what it means. They would say that the animal is homozygous for a majority of dominant characters. Translated to English it means, that first, the animal has in his chromosomes pairs of genes which are alike. If he is a

The Irish terrier possesses a majority of dominant traits. Judging from his offspring when mated to almost any other breed, we should call him prepotent.

guinea pig, he would not have a gene for white coupled with a gene for black. Instead he would have a pair of genes for black. Secondly, the animal would have as many genes which were dominant genes as possible.

The Irish terrier is a prepotent breed. His wire hair is dominant, his rough coat is dominant, his yellow color is dominant, also his lop ears. That is why when a purebred Irish terrier mates with another breed he leaves the pups marked "Irish."

If a black, rough coated, short haired guinea pig mates with one of any other variety, even though the traits are very different, the offspring will look like the black, rough coated, short haired parent. He or she would therefore be said to be prepotent. But if he were not constituted so that the genes were alike, if he had a gene for white and a gene for black, he would not put his stamp on all of his young. He would therefore not appear so prepotent.

Here is a picture of a cross of a long eared foxhound with an airedale. The tail is purposely amputated in the picture.

The result of mating an Airedale with a hound. The Airedale appears prepotent.

In real life it is a full length tail. The pup certainly looks like an Airedale. The Airedale is prepotent.

When a sire has proved by his offspring that he is prepotent and the prepotency is along the lines desired, then the animal is very valuable. He can be used in inbreeding, and there is much more probability that he will not produce defective offspring than one whose producing ability is known to be unstable — one which gives rise to all sorts of offspring which do not run uniform.

Here is a cross of a St. Bernard and a French bull. If the long hair were dominant, we might say that the St, Bernard was prepotent. But the short hair happens to be dominant.

The result of crossing a St. Bernard with a French bull dog.

In other respects the St. Bernard is prepotent. His color, his lop ears, his long straight tail, his longer nose are all dominant. But the fact that such a noticeable thing as his long hair is recessive makes us forget all about his prepotency in other respects.

HYBRID VIGOR ?

Who knows how the old illusion about the superior vitality of the mongrel originated? At the meeting of the American Statistical Association in Chicago, in 1924, I heard a paper read on the subject of immigration. The speaker was discussing race mixture. He alluded to the vitality of the "yeller dog" because he had heard arguments which tried to prove that because the mongrel dog was more vigorous, the mongrel human must be also. He said he doubted the fact that the yeller dog was more vigorous, and ended his paper by saying the advisability of race mixture was still much of a question, and that the old adage was pertinent to this occasion, "When in doubt, don't."

He was right. It is a common opinion that the mongrel dog is a more vigorous, stronger dog than the pure bred. Likewise, that the mixed breed human is also a more vigorous specimen. These two assertions are very doubtful and probably incorrect. If we could stop there, it might not be a dangerous situation, but we cannot. We must consider the future. When the children of these mixed breeds grow up and marry and the traits recombine, they are very likely to recombine in most unfortunate ways.

We have seen how the negro-white mixture makes for a mulatto in the first generation, but that the children may be all shades of black in the next. And with this the hair color must recombine in any of the various possible ways, the curly hair which is also a dominant must recombine, the shiftless disposition, the lethargy, the white man's ambition must all recombine. And when the white man's ambition is combined with the lethargy of the black man in the next generation, not only is the man at a disadvantage, but society as well is affected.

Who would say that the pigeons seen about the parks of cities are more vigorous than pure bred homing pigeons? The cross of a homing pigeon with other breeds frequently produces ordinary common pigeons. Surely these are inferior to the homer with his speed and endurance.

Think of the striking difference between an Australian Bushman standing beside a big blonde Swede? There are races of men and races of animals, and the same kind of things happens when they mix. I know from my studies of human matings, and I know still better from studies of the matings of dogs.

Each breed was developed for a certain useful purpose. Each race of man was developed to suit a certain kind of environment. If 500 white families moved into hot Africa, they would be weeds and would die out in a few generations. They have not sufficient pigment in their skin to protect them from the rays of the sun. The African withstands these rays and thrives. In New York City there are seven times as many cases of a certain destructive disease among the Africans as among the same number of whites.

Why do the Norwegians have such a superfluity of courage? They were bred for the sea. Timid men do not become sailors. They had to live by the sea and the Norse Vikings of

old were *men*. Their descendants are courageous men for the same reason that bull dogs are courageous dogs. They were selected to be courageous. Why has the Nordic a high bridge to his nose? Because he lived in cold dry climates where he had to filter the air which reached his lungs, and also warm it

The difference between the extremes of the size of human beings is indeed striking. Here are two midgets contrasted with a giant.

Why has the African no bridge to his nose? Because he lived in damp climates where the less he warmed the air before it reached his lungs, the better it was for him.

Why is the Scotchman thrifty? Because his ancestors had to be or die. They had a hard time to make their living. Why is the African lazy and improvident? Because he found food

abundant on every hand. He was not selected for this trait. There was no need for exertion, and naturally thrift was not developed. These traits are in the germ plasm and are inherited.

CROSS BREEDING

Owing to the great multiplicity of traits in the breeds of our animals what may we expect will happen when they cross? The result is just the same at it is in the human. Those that have been selected for the same use will make a pretty fair combination, even though it is unstable.

A Percheron and a Suffolk do not make a bad cross, but a Percheron and a Shetland pony produce something which will do the work of neither. A Hereford and an Angus make good beef progeny, but the Hereford and Jersey produce a hybrid which is neither much use for milk production nor for beef. A pointer and a setter do not make a bad cross. A pure bred wire haired and a smooth fox terrier make a good cross, producing wire haired pups. They are both within the same field of usefulness.

When we cross breeds which are widely diversified such as the bloodhound and the elkhound, the shepherd and the pomeranian, and the bull dog with the St. Bernard, the pups are useless. To me race mixture of divergent races, whether of dogs or beef cattle or men, is productive of mongrels which are useless or less useful for the occupations or environments for which the parents were developed.

The hound-pointer cross makes a fair looking dog which is neither like the pointer nor the hound. He is an open trailer, but has lost the hound's quality. He will run foxes only fairly well and will point birds only poorly, but he can be trained to hunt certain game. Can we say that this cross is useful or worthless? Certainly it is no improvement over the parents.

An illustration of the segregation of mental traits is seen in the case of a hound and collie which were crossed and produced some short haired pups which were rather useless for hunting or tending cattle. Two of these pups mated eventually and here are the pictures of two of their offspring. One has short hair and one long.

Now the peculiar thing about these two dogs is that the long haired one is an open trailer and yaps hard on the track of the animals which we have trained him to run. The short haired one has the color and hair type of the hound, but he

is short eared and a still trailer. He is as worthless a cur as I have ever seen.

Their grandparents were a black and tan hound and a sable collie. The hound barks on the track but the collie trails mutely. Their parents were sable colored short haired trail barkers. These traits have recombined in the dogs shown above so that the long haired dog is a trail barker and the black and tan short haired dog trails mutely.

I have investigated countless crosses of dogs of widely differing breeds and can honestly say that I have yet to see a cross which produced better dogs than the parents for their respective uses, although I have occasionally seen specimens which were useful for other purposes but which were not, however, generally productive of their own kind. And neither have I seen mongrels which were more vigorous than the better of their parents. They have not been any more disease resisting, longer lived, larger, easier to keep, more affectionate, or superior in any way to the better of the two parents.

One should not condemn crossing utterly, because without it there would be but few of our present breeds. It has been necessary, to develop all of our useful combinations of traits in the different breeds and will be useful in the future. However, crossing without such objects in view seems to me to be unwarranted and usually productive of no good.

Mutation, crossing, and selection create breeds; pure breeding preserves and protects them, and the usefulness of these depends upon the stage at which they are used.

How often we have read of the wizardry of Burbank, the plant breeder supreme. To the breeder of pure bred animals his methods would have been useless. To the man who wishes to originate new breeds his methods are invaluable. How did he make all of his creations? He used the method of hybridization or, first, produced a whole field of mongrels. Then he watched for desirable recombinations of the traits. These he selected until he had produced the results he desired.

A mare mule and her colt, proving that not all mules are sterile.

But where he could stop with his plants, we would have to continue with our animals. He frequently propogated his desired plants from cuttings, and by other means than breed-

ing and the use of seeds, while we must continue to breed and hope that our new group of characteristics will stay true, as they seldom are kind enough to do. Furthermore, Burbank had a whole field with millions of plants from which to select each year, while we must have a dozen or a hundred animals, thus making the chances of finding our desired one much less likely.

In some cases hybridization between different species, as for instance the horse and the ass, has been productive of animals which can do work which neither of the parent species can do. Unfortunately the offspring is seldom fertile in such cases.

There are a few records of mules which have produced young. Dr. William E. Hastings of Mount Vernon, Indiana sent me the picture of the mule with foal which is reproduced. It was born in a logging camp near Caruthersville, Missouri, and owned by a Mr. Orle Rader. This is one of the very great exceptions to the general rule.

Dr. Hastings has made many experiments in the hybridizing of zebras with horses. He says of them:

"We purchased from Louis Rhue at Aldfelt, Germany an eight months old Grevys zebra stallion in 1912. When this colt arrived home we placed him in a paddock with a filly colt

Grevys zebra stallion used to mate with mares for the production of vigorous zebroid hybrids.

of his own age. We were unable to get him to serve until five years old. After that time he was used as we would use any Jack or stallion. In order to make this stallion more manageable we worked him to harness when two years old.

"When five years old he weighed 900 pounds. The dams of these zebroids weighed from 1000 to 1600 pounds. The zebroids weighed from 1100 to 1500 pounds, they were gentle, easily kept, stood the heat remarkably well, and were good workers to all kinds of farm implements. Four of them were broken to the ring and we think they showed as much intelligence as any horse or mule. My limited experience would lead me to believe that a Grevy zebra is superior to a Jack as a sire for farm animals."

Unquestionably the mule and the zebroid have advantages over both the horse and the jack or the zebra, but in this case we must remember that the uses to which man puts all of these animals are not those to which they were adapted by nature. The uses are exceedingly artificial.

In the case of the zebroids the colts are much larger than the zebra sire. This is most unusual, and in general the size tends to be more like that of the smaller parent. Here, no doubt, is a very useful hybrid but whether it is more vigorous than either of the parents, time alone will tell.

Just why the different species are not fertile with each other has long been a much discussed question. The reason doubtless lies in the difference in the number of chromosomes, or arrangement of genes in their chromosomes.

In the case of wheat, there are some kinds which are known to have but seven chromosomes. Another sort has fourteen, while still another has twenty-one. If the last be crossed with the second, the offspring is fertile, while if the last is crossed with the first, the offspring form no germ cells which are viable.

In the long ages of the past, where the different species were not isolated by geographical barriers, such as mountain ranges or oceans, probably all of those which could interbreed, have done so. When man tries to interbreed them, he finds that it is impossible to make the cross, due to the infertility or incompatibility of the sperm and ova, of the different sorts, or else that the resulting cross is infertile. Nature has tried her hand and already found all of the possible combinations, so that there are none, or few, left for man to accomplish. When we consider those which have been successful, it seems that the greater number of them have been crosses between species which were previously isolated, but which man brought together.

Take the case of the polled Hereford bull crossed with the buffalo cow. The offspring follows the Hereford color pattern, having the white head, and is hornless as well. The bison and the European cattle had never had an opportunity to hybridize until man assisted. The Hereford crossed with the Zebu illustrates the same thing.

In this case the offspring are said to be immune to foot and mouth disease, and anthrax, and also tick resisting, while they are superior for meat production and are thus a worth while addition to the tropics, but, and hereby hangs the tale, the first generation of this cross is all that is dependable. Beyond that the offspring are so variable that they are utterly undependable economically.

Such is the case with all instances in which hybrid vigor is reported. Within the germ plasm are genes which are known as growth factors. Likewise there are inhibiting factors. It

Will the zebroid displace the mule as a work animal? The father of these fine specimens is the 900 pound zebra shown on page 140. Their mothers were mares of about the same size as these colts.

is believed that the increase or decrease of vigor in the instances where it appears is due to a doubling up of these growth factors, or to a splitting up of pairs of recessive inhibiting genes. After the first generation the new assortment of

these factors with different partners will inevitably result in a less valuable offspring.

The mule and the zebroid have thus far been the only economically worth while animal hybrids among the different species. But in the vegetable kingdom we find valuable new creations appearing frequently. These can often be reproduced by cuttings and thus the vigorous specimens be perpetuated. Where seed must enter in, the vigor disappears after the first hybrid generation. Even in the case of the seed corn shown on page 127, the breeder has to keep two strains of inbred stock continually and each year he must outbreed the two inbred strains in order to get the increase he desires. This is an expensive matter and illustrates the lack of stability of the vigorous hybrid.

Hybridization between closely related species which are ordinarily outbred, is not productive of increased vigor, while among distantly related species which will interbreed, it sometimes results in an increase, a few of which crosses prove useful. For the practical man who cannot afford to indulge in experiments, the best advice, if he is contemplating hybridization, is, "When in doubt, don't."

CHAPTER XV

IDEALS: THEIR PRACTICAL VALUE

When you attend a stock show, poultry show, dog show, or field trial, does it ever occur to you to think what the purpose of these exhibitions or trials is? Or do you take them for granted like almost everybody else? Don't do it in the future. The stock exhibitions are one of the greatest agencies for breed improvement ever devised by man.

Watch the judges carefully and see what they are doing. If you go to the horse show you will see a judge scoring the animals. First he has a mind picture of an animal that his imagination pictures as perfection. Next he has in his hand a score card and on this you find that the horse's head, for instance, is given a certain number of points; his gait, his general confirmation, his quality, and other items, different numbers of points depending upon their value to the animals and hence to man. You would find condition was given a very small number of points or none at all. "Why?" you ask the judge.

If he is a good judge, he will tell you that with the exception of geldings, the horses are being shown to determine their value as parents of the next generation, and that their condition at the time of showing had very little to do with their germ plasm unless it was so bad as to interfere with health, in which case such horses would very likely not be in the show ring.

Then suppose you sat down to think over that score card and from whence it came. You see that somebody printed it, and that the printer must have gotten his instructions from somewhere. And then you realize that there must have been a group of experts who devised that score card. No longer do you take it for granted. You begin to imagine yourself one of those experts, and wonder what you would do were you to assist with the preparation of such a score card.

Would you allow such a large number of points for feet and legs? Yes, they are the most important part of the horse because if the legs give out the horse would be as useless as an automobile with a broken wheel. And you couldn't change a horse's leg as you could a wheel. As you consider each of the

points you come to see that usefulness has played a tremendous part in the establishment of the score card, while beauty, you begin to learn, is closely associated with utility.

Actually a score card is merely an attempt to express an ideal in the divisions of one hundred per cent. One hundred per cent represents the ideal, or it should, while the divisions should represent the relative value of the different parts of the anatomy and behavior.

Contrast this excellent system with what some other judges do when they enter the ring; take the average judge of dogs for example. The chances are pretty good that he does not know what the point score is which the fanciers have devised, but he judges the dogs according to what *he* thinks is best. I have seen it over and over again.

I shall never forget the decision of one of these judges at America's most important show. There were only three dogs in the class, two of which were excellent specimens, but the third was off type. He put her first, while the one which was obviously best by its breed's score card went second.

On behalf of the owners, I asked the judge why he had done this, and he replied that one dog was too fat, otherwise he would have given her first. I looked up the point score and found there were no points whatever allowed for condition, and there was fully twenty-five points' difference between this bitch and the one he had put above her. Such things should not be tolerated, but the reason they are is clear; namely, the lack of an ideal, or if there is an ideal, the lack of knowledge of it on the part of most judges and dog breeders.

Not only is the lack of ideals confined to dog fanciers. They are unknown to over ninety per cent of the breeders of all sorts of animals. This condition is what makes for the great number of nondescripts one sees throughout the country. What is the solution?

If we asked fifty fanciers of a breed, each of whom was an artist, to read the breed description and point score carefully and to paint a picture of what they believed the ideal animal should resemble, how much alike would the pictures be? Obviously there would be much difference between them — in some cases *very* much — because the word picture would give each a different specific mind picture.

True type Holstein Fresian cattle. Hitch your wagon to a star. These are the stars of the Holstein breeders.

The artists may be likened to the breeders today. Breeding, well done, is an art. Some breeders are no more artists than barn painters and do their work in just such a slipshod manner. But for the sake of real artists there is needed a specific picture so that no one's mind picture may lead him astray.

In almost every schoolroom in the agricultural high schools and the agricultural colleges where dairying is taught you will find very likely hanging on the wall several pairs of pictures and perhaps a pair of statues also. The dairy cattle associations distributed these pictures and statues of ideal bulls and cows. First each framed an ideal which was so good that they believed it could never quite be attained by breeding. Then they had a noted sculptor chisel the statues until they were the duplicate of the ideal, and they also had an artist paint pictures of these imaginary ideal animals.

The ideals are the stars to which the breeders hitch their wagons.. They do not expect to attain them in their breeding *ever*. If they do, they will have to make their ideal still finer, or else it will no longer be an ideal; in fact, some have raised their ideals several times already.

What is the result? The boys who look at these figures every day develop an ideal. They carry it in their minds continually. Before long, when they think of a Holstein cow, for example, they think of their ideal. They cannot see in their mind's eye any other sort. When they are grown and go onto farms of their own, and the cow dealer comes to visit their farms to sell them some cows they will laugh when he shows them cows which are off type or decrepit. They will tend to buy cows which are as nearly like their ideal as possible, and thus the breed will become improved.

Are you skeptical as to whether ideals have practical value? Read what Mr. Earl J. Cooper, the Extension Secretary of the Holstein-Friesian Association of America wrote me in reply to a letter asking about their value:

"Replying to your letter concerning the influence of the pictures and statues of the True Type Holstein-Friesian cow and bull, would say that it is, of course, hard to give you a definite statement as to the actual value of the True Type models and pictures but we know that the value of these is tremendous in an educational way.

"To begin with the 110 sets of True Type models of the large size are distributed somewhat as follows:

(a) A set is loaned to every land grant agricultural college in the United States as well as several other institutions. These models are continually used in agricultural classroom work to give all dairy students an impression of what a True Type Holstein-Friesian cow or bull should look like. They are used also for many gatherings of farmers, boys and girls club members and others who come to the college for short periods.

(b) Several sets have been sent to foreign countries, also Canada and Alaska. At the present time we have them in New Zealand, Japan, England and Holland and they have become the standard of type in these countries.

(c) A number of sets were presented to the leading dairy papers.

(d) A number of individuals have purchased the sets for their offices where a good many people are able to see them.

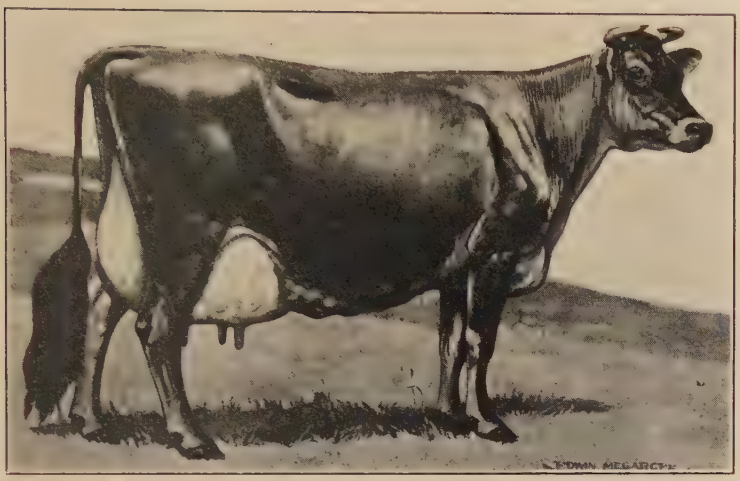
(e) The Association through its Extension Service has shown the models at hundreds of shows and fairs, have exhibited them on many of the better purebred sire trains and they have been used in many window exhibits.

"Concerning the True Type pictures, I will say that hundreds of thousands of the same have been distributed over the United States, Canada, and many foreign countries and have been used by nearly every agency we can think of in the promotion of better type among cattle.

"The results of all of this work are many but the chief result is that our Holstein cattle are showing a marked improvement in type during the last three years."

That looks as if ideals were *practical.*

In order to ascertain just what specialty clubs had formulated anything beyond a description and point score of what their particular fancy should look like, I wrote to all of the secretaries of the major horse, cattle, swine, sheep, and dog clubs in America. I learned that practically all of the commercial live stock clubs had formulated definite descriptions and point scores. To show the extreme care with which the ideal has been considered, the following point score of the American Jersey Cattle Club is presented.



The ideal Jersey cow. The Jersey Breeders have already had to raise their ideal several times.

Scale of Points for Jersey Cow

DAIRY TEMPERAMENT AND CONSTITUTION

	Counts
Head, 7.—	
A—Medium size, lean; face dished; broad between eyes; horns medium size, incurving	3
B—Eyes full and placid; ears medium size, fine, carried alert; muzzle broad, with wide open nostrils and muscular lips; jaw strong	4
Neck, 4.—	
Thin, rather long, with clean throat, neatly joined to head and shoulders.	4
Body, 37.—	
A—Shoulders light, good distance through from point to point, but thin at withers; chest deep and full between and just back of fore legs	5
B—Ribs amply sprung and wide apart, giving wedge shape, with deep, large abdomen, firmly held up, with strong muscular development	10
C—Back straight and strong, with prominent spinal processes; loins broad and strong	5
D—Rump long to tail-setting, and level from hipbones to rump-bones	6

E—Hip-bones high and wide apart	3
F Thighs flat and wide apart, giving ample room for udder	3
G—Legs proportionate to size and of fine quality well apart, with good feet, and not to weave or cross in walking	2
H—Hide loose and mellow	2
I— Tail thin, long, with good switch, not coarse at setting-on	1

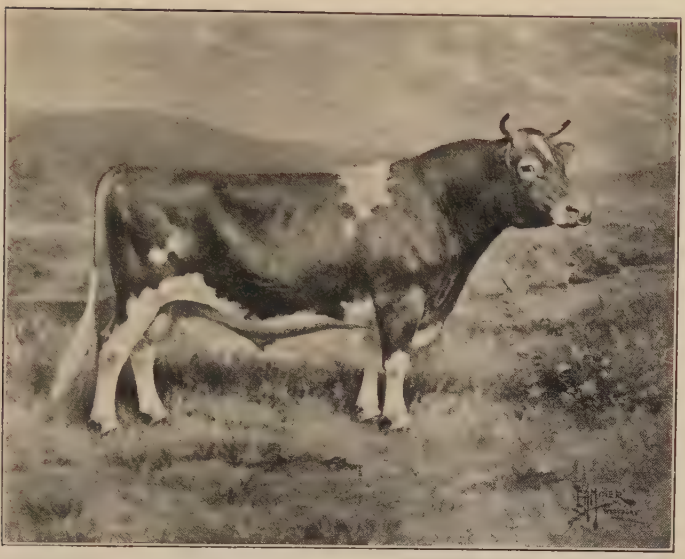
MAMMARY DEVELOPMENT

Udder, 26.—	
A—Large size, flexible and not fleshy	6
B—Broad, level or spherical, not deeply cut between teats	4
C—Fore udder full and well rounded, running well forward on front teats	10
D—Rear udder well rounded, and well out and up behind	6
Teats, 8.—	
Of good and uniform length and size, regularly and squarely placed	8
Milk-Veins, 4—	
Large, long, tortuous and elastic, entering large and numerous orifices	4
Size, 4.—	
Mature cows, 800 to 1,000 pounds	4
General Appearance, 10.—	
A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail	10
Total Score	100

This is most excellent, but none too full and complete. However it is reinforced by a picture of the ideal, and I am sure that no members of that organization would care to forsake the idea of keeping an eye picture ever before themselves.

All four of the principal milch cow associations have gone further than the point score and have had paintings prepared. First, photographs of animals which were the best of the breed, were obtained. Then a committee of experts decided how these cattle could be improved in order to be of greater value.

"What would we like to have our cattle like, if we could; what is the very highest ideal that we can imagine which will yet be within reason?"— that is the question they asked themselves, and after they had answered it, they instructed an artist to retouch a photograph until it represented the dreams of the



The American Guernsey Cattle Club created these ideals which are better than any breeder can hope to reach for many cattle generations. If these ideals are approximated they will have to be made still better.

most expert fanciers of the breed, and from that to make a painting.

The ideals are based on utility as well as beauty. No need to comment on the different characteristics of these ideals —

The ideal Ayreshire. It is difficult to see how a cow could be bred to be quite as fine as this, but no doubt the future will see that happen.

every breeder knows that there are points which are associated with certain qualities, and hence he wants to have cattle which possess them.

Of the beef cattle associations, the only one whose secretary reported a picture of their ideal was the American Shorthorn Breeders Association, and he wrote that the picture was in process of preparation.

None of the horse associations had formulated ideals further than descriptions and point scores.

None of the swine associations had done better although some of their descriptions leave but little to the imagination, still they would be far more valuable if they had pictures to accompany them.

The same applies to the sheep associations.

But when we come to the dog clubs, we find a conglomerate condition of affairs, which is typical in a certain sense. The collie and St. Bernard breeds do not so much as have a point score. The descriptions are full, but the judges must have a hard time to know what points about the dogs are most important. As the secretary of the Collie Club wrote me, "Collies are judged in the ring by comparison and not by a point score."

The German Shepherd Club has gone just a step further, adding several diagrams to the description showing how the build should appear and also the ideal gait, and pictures of the proper tail carriage and formation. This is an admirable improvement, and the next best thing to a picture of the ideal.

Most of the other clubs have both descriptions and point scores some of which are totally inadequate, and such that no judge could follow very well. Most of them ought to give more attention to improvement and when they have improved, insist that the breed be judged according to that standard.

The Chesapeake Bay breeders have not only an excellent description and point score but give dimensions in inches, of their ideal.

CHESAPEAKE STANDARD

GENERAL DISQUALIFICATIONS

1. Black or liver colored.
2. White on any part of body, except breast, belly or spots on feet.
3. Feathering on tail or legs over 1¾ inches long.
4. Dew claws, undershot, overshot or any deformity.
5. Coat curly or tendency to curl all over body.
6. Specimens unworthy or lacking in breed of characteristics.

HEAD

Skull broad and round with medium stop, nose medium short-muzzle pointed but not sharp. Lips thin, not pendulous. Ears small set well up on head, hanging loosely and of medium leather. Eyes medium large, very clear of yellowish color and wide apart.

NECK

Of medium length with a strong muscular appearance, tapering to shoulders.

SHOULDERS, CHEST AND BODY

Shoulders, sloping and should have full liberty of action with plenty of power without any restrictions of movement. Chest strong, deep and wide. Barrel round and deep. Body of medium length, neither cobby nor roached, but rather approaching hollowness, flanks well tucked up.

BACK QUARTERS AND STIFLES

Back quarters should be trifle higher than shoulders, they should show as much power as the fore quarters. There should be no tendency to weakness in either fore or hind quarters.

LEGS, ELBOWS, HOCKS AND FEET

Legs should be medium length and straight, showing good bone and muscle, with well webbed hare feet of good size. The toes well rounded and close pasterns slightly bent and both pasterns and hocks medium length—the straighter the legs the better.

STERN

Tail should be medium length—varying from: Males 12 inches to 15 inches, and females from 11 inches to 14 inches; medium heavy at base, moderate, feathering on stern and tail permissible.

COAT AND TEXTURE

Coat should be thick and short, nowhere over one and one-half inches long, with a dense fine wooly undercoat. Hair on face and legs should be very short and straight with tendency to wave on the shoulders, neck, back and loins only. The curly coat or coat with a tendancy to curl, not permissible.

COLOR

Should be as near dead grass as possible, varying from a tan to a faded brown.

WEIGHT

Males, 65 to 75 pounds; females, 55 to 65 pounds.

HEIGHT

Males, 23 inches to 26 inches; females, 21 inches to 24 inches.

SYMMETRY AND QUALITY

The Chesapeake dog should show a bright, happy disposition, and an intelligent expression, with general outlines good and denoting a worker.

Color and coat is extremely important as the dog is used for duck hunting. The color must be as nearly that of his surroundings as possible and with the fact that dogs are exposed to all kinds of adverse weather conditions, often working in ice and snow, the color of coat and its texture must be given every consideration when judging on the bench or in the ring.

SCALE OF POINTS

Head, including lips, ears and eyes	14
Neck	6
Shoulders	10
Back quarters and stifles	14
Elbow, legs and feet	10
Stern and tail	12
Symmetry and quality	10
Coat and texture	13
Color	11
Total	100

APPROXIMATE MEASUREMENTS

Length head, nose to occiput	9½	to	10
Grith at ears	20	to	21
Muzzle below eyes	10	to	10½
Length of ears	4½	to	5
Width between eyes	2½	to	2¾
Grith neck close to shoulder	20	to	22
Girth of chest to elbows	35	to	36
Grith at flank	24	to	25
Length from occiput to tail base	34	to	35
Girth forearms at shoulders	10	to	10½
Girth upper thigh	19	to	20
From root to root of ear, over skull	5	to	6
Occiput to top shoulder blades	9	to	9½
From elbow to elbow over the shoulders	25	to	26

The Masters of Foxhounds deserve congratulations for their foresightedness, in having prepared the first picture ideal of their breed. The secretaries of the English Springer Spaniel

A creation of the imagination of the Masters of Foxhounds. No such dog ever lived, but it is hoped that such ideals as this will hasten the day when foxhounds will be close to it.

Field Trial Association and the American Sealyham Terrier Club wrote me that at present they were preparing paintings of their ideals. Other clubs will undoubtedly follow in their footsteps.

What if all the clubs did this for their breeds? What if, for a nominal charge, each club furnished its breeders with a statue of the ideal, and an ideal which had been developed by *scientific knowledge* to be the best for its purpose, and if every breeder knew this ideal so well that when he thought of his breed he thought of it in terms of his ideal, then think how quickly the breeds would tend toward a single standard of perfection.

What constitutes the ideal of many of the fanciers today? The ideas of a few judges. And despite the fact that their judgment is usually good, it is sometimes perfectly ludicrous.

As an example of the way judges can spoil certain breeds whose fanciers lack ideals or do not insist upon judgment on the basis of their score, think of the change which has come over some breeds which I dare not name for fear that their admirers will have emotional spasms rather than thoughtful deliberations. I can think of at least eight breeds of dogs which are slowly being developed into what is known to the medical profession as microcephalic idiots.

When a human is born with a head shaped so that there is not sufficient room for the brain, the person usually does not

A human microcephalic idiot. Note the small size of brain case. His body is large and strong but he is incapable of usefulness in the world because he cannot be educated. To have education we need educable people.

have the brain capacity of a Socrates. The smaller it becomes, other things being equal, the less ability he has. This usually makes the subject fit for an institution for the feeble-minded.

Through long centuries of the past, dogs have developed with increasingly larger brain cases. It is the easiest kind of thing to select them for diminishing capacity, but it is a real achievement to develop a larger brain case. That is what the breeders should do –select for large brain cases and quality to accompany it– rather than for smaller and smaller brain cases.

What would we say of the clergymen who united in marriage a pair of microcephalic idiots? But we praise the person who mates dogs and produces young which are becoming more and more incapable of dog sense every day.

Were I to judge some of these breeds, I should disqualify immediately every specimen which had a brain case below a certain size, and begin my judging with the dogs that had ability. I cannot voice this protest strongly enough. The breeders do not realize how far this thing can be carried, and the judges are to blame.

Almost every breed of domestic animals has a definite standard which has been set by those who ought to know, as its

Not the ideal, but such a picture would be used as the basis for painting the ideal Shropshire. This individual is one of the best ever bred.

perfection. Every breeder ought to get acquainted with this standard and adhere to it. And more than that it is the best possible investment for rapid breed improvement, to draw a

picture of that ideal, just as it has proved to be with the dairy cattle associations. If this is done the men who draw up the ideal animal will find that they are visualizing an animal not wholly like the one described in the point score.

Eugenists are now trying to inculcate ideals of perfect manhood and womanhood into children so that such a thing as marriage with defective stock will not enter the heads of these children. What a wonderful thing it would be for the race of men if all of our children were to have high ideals of what their mates should be.

Some boys, passing an apple cart, will steal an apple. Others passing an apple cart will stop and think, "Now it really isn't right to steal that apple, so I won't steal it." Other boys, on account of their training, do not have to stop to think,—they know without thinking that the apples are not theirs and they never suffer such temptation. So it is with the training of boys and men.

Some will marry the first girl they see, whether she is an epileptic, a prostitute, or insane. Others will stop and think, but being in love they will marry her. To others the idea of marrying such a woman would not even enter their heads, so they pass by without a thought.

So it is also with the breeders of animals. Some men will mate to the first male they find. Others will stop to think and pass by if it happens to be convenient. To others the idea would never enter their heads — the male is too far removed from their ideals.

None of the great breeders of the past have been of the hit-or-miss variety. Those who have accomplished real results have been the men who stayed with breeds which they had chosen as most desirable for themselves, and they have used the best intelligence they possessed in bringing the breed nearer to perfection.

Once in a while a rich man will decide that he wants to have some dogs, let us say, and then will proceed to buy dogs here and there without regard to their ancestors as long as he gets show specimens. He mates these and expects that he has done a great thing for himself. But it is odd that he so seldom accomplishes the results that the old breeder does.

CHAMPIONS

The animal which has been awarded a championship is the one which is in greatest demand at present for a sire or dam. And yet under the present method they are, unfortunately, not always the most valuable. The rigid insistence upon a point score would help greatly to remedy this situation. I believe that all animals of all breeds should be scored at every show and the score cards filed with their registrations. It would take a little longer than the present method but the advantages would more than compensate. Then I believe that the point score of every animal should be preserved. If the judges had in hand the point score and in mind the ideal of each breed they were judging, we should see different animals winning best-in-the-show. There would be very few individuals with point scores of over 95 where the ideal is 100, because few animals could be over 95% perfect, or the associations would have to make their ideals higher when practice was treading so closely upon the heels of perfection.

Then there should be a definite minimum of points for an animal to score before he or she could be made a champion. As it is now, in many breeds all that is necessary to become a champion is to score a certain number of firsts or a definite number of points represented by winnings. Thousands of very poor individuals have in the past had a "Ch." added to their names when they no more deserved it than the veriest mongrel. Once in a while a courageous judge has strength of character sufficient to refuse to give first prize to inferior animals even though they are the best of a very poor string. Such men are the best agents of breed improvement. We need more like them.

The recorded point score has another advantage. All of the best animals in so large a country as the United States cannot always be brought together in a show ring for comparison. The recorded score would make the best truly the best whether it was in California, Florida, Maine, or Texas.

The show ring for championships is the equivalent of field trials among animals where field trials are possible. How many times have most of the best been gathered together in one elimination heat of a field trial? How many times have large numbers of the very best animals competed together for honors in the show ring and championships? In some smaller

show the animal which stood tenth in a great show, comes away with the blue ribbon. We have all seen this happen many times. The recorded point score would not eliminate this sort of thing but would show the true worth. Just as in an athletic meet the committee tries to put one extra good man along with several poor runners in the elimination heats, so the recorded point score would tend to show real merit and not relative merit, when the comparison method alone may be, and often is, wholly unjust.

Even the suggestion of so mild an improvement as preserving all point scores from shows will be so new and hence so repugnant to some tradition-bound persons that I hesitate to make the next proposal on that account, but let me risk it anyway.

I believe that there is need for an advanced registry for all sorts of animals—not merely an advanced registry for milk

The ideal Dalmation. The fine points of the breed were carefully considered in creating this target at which the breeders are aiming.

production or racing records but one for general excellence. This would not be difficult to accomplish.

At a certain time each year a committee of judges should call on all of the breeders of a certain breed who have nominated animals for the advanced registry. Only mature animals would be scored. In the case of small animals which could be transported easily they might arrange to score localities at one central place. Each nomination could be accompanied by a fee. At the inspection, the animals could be scored in detail rapidly, a copy of the score card sent to the registry headquarters and a carbon copy left with the individual. Animals which obtain a score of over a determined mark would be admitted. On this basis whole herds or kennels would sometimes be admitted.

Having had considerable experience with the Fitter Families Contests sponsored by the American Eugenics Society, I realize how easy this would be of accomplishment. When fifty human families can be given a thorough physical, mental and hereditary examination many times as complicated as would be necessary in the case of animals, all in the space of a few days, it will be seen how simple animal scoring would actually be. The judging is done by disinterested persons from the scores received, and the winners are easily chosen. Each one passing a definite high grade is awarded a medal. For assistance in their own work, intelligent breeders can then score all of their poorer animals themselves. This would give them a wonderful record to use and make it easier to compute the hereditary promise of general excellence. General excellence is a composite of all of the traits of the body but it may, by careful methods, be predicted within reasonably narrow limits.

This is a new age. Heretofore we have first "tried it on the dog." But in this instance we have tried it on man and now it behooves animal breeders to follow the successful example.

CHAPTER XVI

BREED IMPROVEMENT

Oh, if every breeder of animals knew the genetic basis of breeding, how easy it would make the whole thing! And how much more interesting! The reader has, I hope, by this time acquired a substantial knowledge of that basis. I have tried to make it as understandable as possible, and now that it is mastered let us consider the secret of good breeding when a man is not wealthy and must make his money count. How could such a man apply the foregoing?

I believe that it is summed up in the old proverb which Dr. Jon Alfred Mjoen found in the western part of Norway: "Marry not the girl who is the only good girl in the breed." This is an expression of two thousand years of human experience, and it holds true for animals fully as well. Breed not to the animal which is the only good animal of its breed or strain or family.

Considering this proverb, we can see how well it applies to this problem of breed improvement. Because of the fact that so many of the characteristics of animals for which we breed are governed by multiple factors, it behooves us to think mainly in terms of them. Therefore, we see that it is possible by the proper combination of genes to bring excellent stock out of mediocre, when most of the relatives of that mediocre stock have been of high type.

Abraham Lincoln, to my mind, is one of the finest examples of heredity which the world has ever known. His mother has been described by all as a woman of unusual ability and superior temperament. Despite the fact that she is supposed to have been an illegitimate daughter of a fine woman, there is every evidence that Nancy Hank's father was a man of genuine capability.

Here, as in so many instances in the past, social position acted as a barrier. But in our study of the germ plasm and inherent value, social position, prestige, financial rating, and all such considerations are will-o'-the-wisps—an illegitimate child is just as much related to the father and mother as a legitimate.

At any rate the fact that Nancy Hanks' mother had the strength of character to hold the father's name a deep secret speaks well for her. Nancy had biologically but not socially, a glorious heritage, and therefore was so glorious a woman.

But Thomas Lincoln, Abraham's father, is not supposed to have been such a worthy. None can doubt that he did possess a rough and roaming disposition. But let us not conclude hastily that that is altogether an evidence that he was good for nothing. Anyone who knows life on the frontier does not judge it by present-day apartment house standards. It first of all took a temperament with real character to pull up the old stakes and migrate to new land. This he did easily. It took strength of character of a certain sort to eke a living out of the wild. Not many of us are trying to do it today. We find city life too comfortable. Thomas Lincoln and Nancy, his ever faithful wife, could have stayed where it was comfortable, but a great something, which others never felt, urged them to do things. And that urge was passed on to Abraham. Without it, would he have had the pertinacity to lead out in political and moral fields, as his pioneering father did on the frontier? No indeed! The recent study which Professor Ellsworth Huntington and I have made which was published in *The Builders of America,* demonstrates conclusively that there is a certain missionary spirit which is possessed by many which makes them dare new things. Some of the very best of the young men of our colleges take up missionary work and go to far away lands for a pittance of a salary, because they somehow feel that there is nothing at home quite big enough for them to do. And their children stand far in the lead of the children of men in any other profession, judging by their success and ability. Associated with the missionary zeal—that something that drives men in search of the Holy Grail, call it whatever you like—are other characteristics which make for genuine greatness.

Now let us study his near kin to see what we should expect of Thomas as a father. Ah, we find that his family came to Virginia from Massachusetts, where they were a great family of iron foundrymen. Previously they had lived in England. And what drove them to America from England? That same pioneering spirit! That same dissatisfaction with unsatisfactory conditions at home! They had to find new worlds to conquer.

Every student of human heredity would do well to review Dr. William E. Barton's writings on the ancestry of Lincoln. It is remarkable to note from them the continuity of Lincoln traits through other members of the family. One instance, from "'Mord' Lincoln, the Woman-Hater", will suffice:

"When the two men met in front of the little store at Fountain Green, it was easy to see that they were close akin. Their eyes and hair and gait were all alike Abraham was taller than his cousin Mordecai, but Mordecai was a tall man, and his two brothers, Abraham, who died in 1852, and James, who died in 1837, were also tall men of the Lincoln type."

Many of the Lincolns were skilled artisans and there are still preserved, many excellent specimens of the handicraft of Thomas Lincoln, in the form of furniture.

Apparently, therefore, Thomas was one of a family pregnant with potential greatness. When he married the wonderful Nancy Hanks, what else could we expect than that their children would be of high grade? Our expectancy has been fulfilled.

Chief Justice Harry Olson of the Municipal Court of Chicago relates an interesting episode which is new in the study of the heritage of Abraham Lincoln. This is just as he said it when he laid a wreath upon his tomb.

"I heard a story the other day that I have not seen in print. Mr. Henry B. Bale, an insurance lawyer in Chicago, told me, when a boy, he lived in Norwich, England, settled by many people of Scandinavian origin, as the names over its shops indicate. Mr. Bale was a choir boy in St Andrew's Episcopal Church until he was 11 years old. He said when he was there he never read the inscription on an elaborate bronze tablet under one of the windows of that church, but upon returning with his wife to visit the Norwich church he read it and he was struck with the name 'Abraham Lincoln,' a great businessman of the district, who died in 1640. He said the mural tablet must have cost a large sum of money for those days. While Mr. Bale was reading the tablet, the janitor came up to him and said, 'I found an old booklet in the basement written by a former pastor of this church, when your Abraham Lincoln was President of the United States.' Mr. Bale learned from the booklet that the Abraham Lincoln of

the tablet had three sons, Abraham, Mordecai and Thomas. Abraham, Mordecai and Thomas are names that run through the Lincoln family. One of that family came to the United States from Norwich, England, on the second or third trip of the Mayflower, and settled at Hingham, Massachusetts. His brother followed a few years later. His son, Mordecai, settled in Pennsylvania. Mordecai's son, John, was the father of Abraham Lincoln, the grandfather of our Abraham Lincoln, whose father was Thomas Lincoln. Here we see traces of the important heredity. The pastor, author of the booklet, corresponded with President Abraham Lincoln with regard to it, and Abraham Lincoln's letter was reprinted in the booklet in which he said that he remembered of no family record and no spoken word, but there was a general understanding that his family were English.

"President Lincoln requested the pastor to be informed of the result of his genealogical search. The pastor then investigated through the Public Library of Boston and found the Abraham Lincoln honored in the church of St. Andrew, Norwich, England, was a progenitor of the Abraham Lincoln who was President of the United States But we don't have to rely upon genealogy to see that Lincoln was finely bred. That magnificent face; the fine character and intellect fairly shone in it! He was one of the best types of the Anglo-Saxon or Nordic race ever born. It is time that our school children were disabused of the idea that because he was born and lived in a log cabin, Lincoln was of scrub human stock or that such stock can produce a Lincoln."

"Lincoln inherited the qualities that made him great. Ever since his death, environment has been credited with his success, and his parents, ancestors, and the race from which he sprung have been ignored as factors of supreme importance in his life. But now the science of biology—the youngest of the sciences —discloses the secret of his power and proves that he was the product of a great heredity.

"The discovery and re-discovery of Mendel's Law of Heredity, the recent knowledge that the emotions govern behavior more than the intellect, that the chromosomes, those microscopic particles, forty-eight in every human being, half of which are inherited from each parent, carry the different traits which make us what we are, and that environment does not change nor affect these chromosomes in the slightest—all this

comparatively recent knowledge – must, and has changed our views of the source of Lincoln's power."

We could go on studying human families like this for hundreds of pages, but there is no need. We are interested in

This magnificent Newfoundland was a great son of a great family of a great breed.

animals which are under our control as well as human matings which are not, except in our choice of our own mates.

There was a Percheron stallion in Massachusetts which was a winner. Before being purchased he was carefully inspected

by a group of farmers who had clubbed together. They studied the horse and nothing more. Of all of his colts, even from genuinely excellent mares, I never saw one which was nearly as good as the stud. I had occasion to study into the pedigree and later saw his mother, and then I understood She was a very poor specimen indeed, and his father was only fair, judging from a photograph. It was so evident that these farmers had bought the best male of a poor family that I do not now understand how they expected to have excellent progeny.

Contrast this with a man with whom I am well acquainted who decided that he was going to take up the breeding of bloodhounds because he admired them so much and wanted an outlet for his interest in breeding and training dogs. He had but little money to spend on his hobby, and he wanted to make that money go as far as it would. Therefore when he had an opportunity, he bought a male which he learned had sired many champions but was not quite as good an individual as he would have liked. He got the pedigree and found that this dog was descended from some of the grandest bloodhounds that ever lived in England or America. Indeed, all of his eight great grandparents had been champions. So he spent his hard earned money and made a start. Then he found a bitch which was a pretty fair representative, but was lacking in weight and wrinkle. He bought her for $50. But before he bought her he investigated and learned what he could about her parents and some of her near kin and again found many champions in the pedigree, and better than that, both her father and mother were two of the most successful bloodhounds in handling human tracks in America, and their photographs showed that they were dogs of a very fine type. Then my friend found another female sired by the dog which had a bigger record of convictions than any living dog, and was an extra fine type as well. He paid for her by allowing her former owner several services from his stud dog. And with this start of three dogs which could be said to be three animals which were poor specimens of great families, although they were not bad in any instance, this man has built up a pack of bloodhounds which are remarkable. His total outlay was in the neighborhood of $150. plus the cost of raising the dogs to maturity which the sale of pups has more than covered. I do not know of any pups from any of his litters which could

be called poor animals. I know of several which have been most excellent, far better than their parents. Now he uses his best for his breeding stock and he knows their germ plasm because he knows what they have produced, and therefore what he can expect.

In further contrast, I want to compare the results obtained by another breeder of the German shepherds. He bought and imported a stud dog which is one of the finest in existence, at a cost of over $1,000. For a mate he bought a dog for which he paid $600 and which is likewise a magnificent specimen. I saw a litter of pups from these dogs at a year old. The difference was startling. There were two pups which were truly wonderful dogs, nearly as good as the parents, but there was one pup which surely would not have passed for better than a second rate specimen. It was far from what a good shepherd should have been. And some of the other pups were only medium as far as quality is concerned. The former breeder can sell excellent dogs from his stock for just what they are, while the latter has to sell many of his dogs on the reputation of their ancestors, rather than on their own real worth.

These illustrations should make the subject clearer.

From a breeding standpoint, the sire or dam which is the poorest individual of a wonderful family, providing he or she also is a good animal, is far better than one which is a good individual but the best individual of a poor quality family. So whether one is looking over the matrimonial market from a personal viewpoint, or the live stock market for mates for one's animals, the old Norwegian proverb should be ever in mind, "Marry not the girl who is the only good girl in the breed."

When a breeder has done the very best that he can do with the stock he has at hand, there are only two ways in which he can improve it. The first is to wait for a mutation, and that is practically hopeless. The second is to obtain some germ plasm which is better than that of his own stock.

The former way is hopeless because mutations occur only about once in 50,000 individuals, and that does not mean that the same trait changes, but simply that some trait changes once in 50,000 individuals. Taking all of the animals in the world of the same breed, it is likely therefore that among the total there may be mutations which are in the right direction. Probably the increase in all faculties has come about in this

way. Milch cows, racing horses, beef cattle, fat hogs, record hens, racing pigeons, tracking dogs and a thousand other animals and birds, have gone along in the direction man chose by the selection of these mutations, infrequent as they are.

The lucky breeder who discovers the mutation usually incorporates it in his stock until he has a surplus, and then offers his surplus for sale to those less fortunate. For instance, foxes are monogamous. For years it has been necessary to keep an equal number of males and females on the silver fox

The pointer is the result of a long series of selected mutations.

ranches so that the animals can be paired. In several instances there were mutations among males, and polygamous males were the result. There were only a few such instances but from these few there have come hundreds. (The females are all polygamous). One of the largest ranches is now, in 1928, preparing a new ranch and planning definitely on keeping one polygamous male for every four females, thus cutting down their investment 35 per cent while obtaining the same results. When one remembers that a good pair of silver foxes cost from a thousand to two thousand dollars, and that many ranches keep fifty or more pair, it will be seen that this mutation results in saving an investment of upwards of $20,000 to a single ranch. The economic value to the whole industry is tremendous. Now the fox farmers need to find a mutation which will bear two litters of young a year as dogs do, and they can again cut down on their investment. This is but one illustration of many that might be given. The fox ranchers had done all they could until nature came to the rescue, and

then the germ plasm of these new individuals was distributed. In the future the improvement of silver foxes can go forward much more rapidly than has been possible in the past. It will be practical to depend upon the better males without any need to resort to the poorer kinds as it has been done formerly, and is still done to some extent. Furthermore, there will be far less use for males and therefore excellent specimens will be distributed to others in larger proportions, just as is the case with almost all other animals. The improvement is thus accomplished mostly through the males whenever animals are polygamous.

This brings us to the baffling question of selecting an animal for breeding or other purposes while it is still very young. That is the time when most animals are purchased because the breeders desire to dispose of their surplus stock as early as possible. Probably ninety per cent or over of dogs are purchased while they are puppies; the cattle breeder disposes of the majority of his stock when they are calves; pigs are generally sold when they are six to eight weeks old; and millions of day old chicks are sold annually.

How can one tell by an examination, without knowing the ancestry, what the individual which he selects, will look like at maturity? Or for that matter, how can he tell from among a litter which will be best?

I always make it a point to inquire of old breeders what is the best way—what is their way of doing it. They almost unamimously agree that it can't be done.

When I am asked to select a young animal from a litter I prefer not to, because those which show most promise at six weeks of age may not continue their development at the same rate until maturity. Among my own animals, I have watched the runt of a litter develop to be among the best, and those which showed most promise, turn out poorest.

Just why these things occur we do not know. In the germ cells there are genes which inhibit, just as there are genes which develop. We can't say the Clydesdale horse is a giant because of genes which determine giantism or because of lack of inhibiting genes.

We can't say by looking at a six-weeks-old bloodhound puppy where its ears will stop their growth. In one, the inhibiting genes may be lacking, and the ears go on increasing to enormous lengths. In another the brake is put on sooner. We can't say how a Yorkshire hog's form will develop, for if there

Can you select the one which will turn out to be the best? Can you do so for young animals of any kind? If you can the breeding world wants to know your formula.

is a positive way it has not been made public.

In the case of human beings, I remember how the originator of the Better Babies contests once wrote to a leading eugenicist for endorsement of the idea. He wisely replied, "A prize winner at two may be an epileptic at ten."

That one remark led to the Fitter Families Contests which are now replacing the Better Baby Contests at so many state fairs. In these, the whole family is brought in for mental, physical and hereditary examination instead of only the baby for a physical examination. Even experts have trouble in predicting how a baby will turn out without knowing the family history from A to Z.

In short, the question of selecting a young animal in its early days is like trying to tell which of our own children will turn out to be nearest to our ideals for them, while they still are in the "cute" stage, when their little limbs are short and plump, and they are asking us to many questions.

One can choose the animal on a color basis reasonably well in early youth, and there is some indication that ear length and a few other considerations can be predicted. Too often, however, the teatman or "hip-pig" which for some weeks looks smaller than the rest, has been rejected as a runt, only to have it turn out to be the best of the litter.

There are three explanations, any one of which might explain the cause of the differences in size among the young of a litter at birth:

1. The proximity of the food supply. Those embryos which are farthest from the source are not likely to obtain as much nourishment as are those nearer to it.

2. The distribution of the embryos within the uterus. If three are attached closely together there is every likelihood that one or more will obtain less nourishment and therefore be smaller when born.

3. The difference in inherent vitality of the embryo.

As a matter of fact the hip of the mother has nothing to do with the size of the embryos. The person who invented the term "hip-pup" had a distorted idea of the position of the young within the mother. As we shall see in the chapters on the physiology of reproduction, the young of litter-bearing animals are carried in a V-shaped uterus or womb, and the point of the V. is toward the rear of the animal, while the ends of the V are attached to the sides about midway along the abdominal cavity, thus precluding the possibility of pressure on the young by the hips of the mother.

Red Red Cross Cross Silver Silver Silver Black

One of the achievements of modern breeding. Above are the color phases of the red fox. These colors all may be seen on the fox ranches of the country, although some breed only those toward black end of the scale. The solid black fox lacks the red or silver color entirely. A black crossed with a red gives cross foxes. If crosses are mated with blacks the pups tend to be silvers. This was the method employed in the establishment of the silver fox industry. (From U. S. D. A. Dept. of Animal Industry).

PART II

THE PHYSIOLOGICAL BASIS OF BREEDING

PHYSIOLOGY OF REPRODUCTION

Wordsworth said, "To me the meanest flower that blows can give thoughts that do lie too deep for tears." A flower is a beautiful entity, but when its petals, its stamens, its pistil, and its ovary are taken apart, and they are put into little piles which we are about to analyze, it loses, in one sense, its beauty. Then if we begin to study these separate parts and to inquire why they are as they are, the flower begins to take on a new type of beauty for us. It becomes more than a flower. Each part is now even more interesting than the flower had been when it was a unit. The color, for instance, was developed to attract the eye of the insect. The ovary is set away from the other parts where it is protected, and it is the part of the flower for which the rest exists. The perfume which it wafts into the air is but to attract the insects, just as the color does. The pollen covers the bee's legs, and when the bee flies to another flower, it leaves some of it there and thus fertilizes the ova. When the fertilization is accomplished, the petals fall away and the fragrance ceases. The part which has been the protection of the ova, becomes enlarged and grows, as in the case of the apple, to an immense size all for the purpose of appealing to some animal which will carry it away to scatter the seeds abroad, and to protect the precious seeds within. Indeed the flower does give thoughts that lie too deep for tears.

But if the flower is wonderful, what can we say of the reproductive systems of the higher animals? If the flower brings deep thoughts, what can we say about the great beauty of the arrangement in the animals which accomplishes the same purpose as the flower, and in much the same way?

To one whose mind sees things in their true prospective, there are many facts concerning sex that are wonderful beyond comparison. To the man in the slaughter house the organs which he removes from the cattle and swine are "entrails." To the biologist who sees the inter-relatedness of things, the parts which the butcher throws away are as interesting as is the flower to the most ardent botanist.

And what could be more wonderful than the generative organs of life itself? Those tiny fragile cells within the protective mechanism of the mother, those tiny cells within the body of the father, the mechanism for transferring the one to

the other, and the mechanism for the receiving of one by the other, the beautiful manner in which the two cells join, and the progeny becomes attached to the proper place in the mother, the development of the foetus, its nourishment, and finally at the appointed time its safe delivery into the outer world, with all of the marvelous processes that attend. The wonder of a single organ can give thoughts that do lie too deep for tears.

Surely, no subject is more worthy of study than the physiology of reproduction, and surely there is not any which can give us a better appreciation of the beauty and wonders of nature.

When we were in school we were taught about the flower, learning its minutest details. But why the false pride that prevented our being taught the same facts about the human body? "Well, it just isn't done," they said. But those of us who give thought to the subject know that this would be a better world if we had all been taught the story about the animal mechanism which corresponded to the reproductive mechanism in the plant.

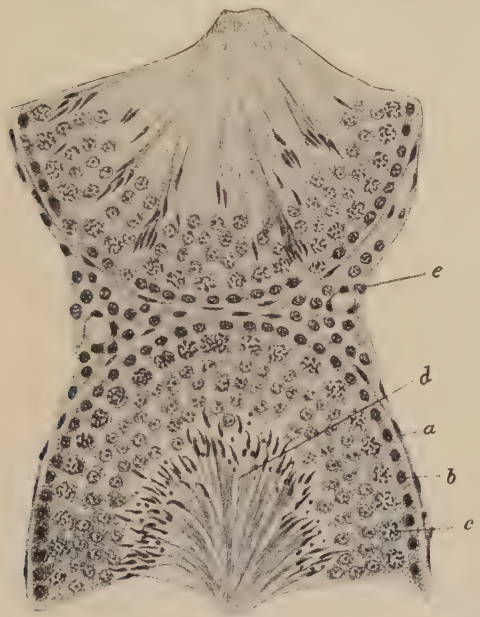
Let us therefore study the general facts about the male and female reproductive organs as they apply to all mammals, including man. Then I propose to take the reproductive mechanism of the female dog and use that as an illustration of the more intricate processes which attend the mating cycle.

After the general and specific facts have been made clear for the dog, we can then take up the application to each major species of domestic animals, and there we shall see diagrams showing the mating cycles as well as pictures of the female reproductive systems.

CHAPTER XVII

THE MALE REPRODUCTIVE SYSTEM

The reproductive organs of the male are more simple than those of the female. We shall consider them first. Of course, the principal organs are the testicles, which are located within a sac called the scrotum. The other organs are accessories to them. Each testicle is enclosed within a fibrous covering. It is well supplied with blood, which furnishes the food for the cells within it. The whole is filled with tiny tubules which



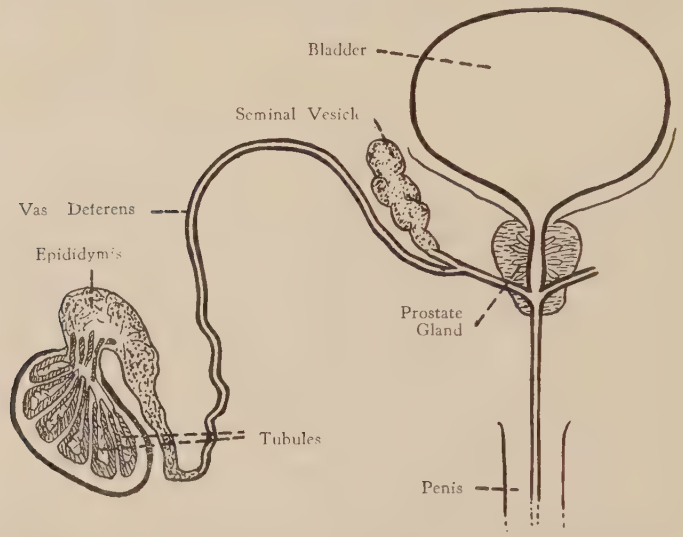
Section through two tubules (the little tubes in which the sperm are manufactured).
a—membrane.
b—primary germcells.
c—developing cell.
d—fully developed sperm
e—cells in connective tissue.
(From Marshall)

hold the original germ cells, that continually divide and, as we have already seen, become sperm. These little tubules are hollow, and there are openings so that the newly manufactured sperm may escape and begin their journey.

The illustration shows a tubule with many cells in all processes of division. and some in the resting stage. In the outside layer are to be seen the original cells, and as they divide the newly formed cells work toward the center, each step

bringing them nearer to becoming sperm. There are innumerable tiny tubules which conduct the sperm toward the tubes, and these in turn lead into the main tube, called the Vas Deferens, and commonly referred to as the vas. As will be seen, one vas from each tesicle enters the abdominal wall of the animal, and passes completely around the bladder above which it joins the vas from the other testicle and thence to the prostate gland.

Why did not nature in her infinite wisdom place the testicles within the abdomen where they would be better protected,



rather than on the outside? That is a reasonable question and still it is not one which would occur to a person without an inquiring mind.

Almost all male mammals carry the testicles outside of the abdomen. The reason is that the male germ cells must have a cool environment in order to develop. With almost all mammals the testicles are contained in the abdomen for the first part of their lives. While they are within the abdomen no sperm are manufactured and not until they descend into the scrotum do they perform the duty for which they are intended. Heat prevents development and cooler temperature stimulates it.

While I have never known of the case of a dog which retained both testicles in the abdomen, I have known of such retention in other species of animals. These males are infertile until a surgical operation, which brings the testicle into the scrotum, sometimes renders them fertile.

It is frequently wondered what becomes of the sperm which are not used. They die, disintegrate and are absorbed. There are in the blood certain cells known as leucocytes whose task it is to renovate. They absorb the undesirable cells and germs in the body, and when the sperm have died and disintegrated they are absorbed by the leucocytes.

In some animals which have a definite breeding season such as sheep, the testicles have a resting period, but with animals which must be ready for the fertilization when the females are likely to be ready at any season of the year, there is no resting period.

This explains why a male animal, which is in otherwise good condition, is fertile the first service. If the sperm were not absorbed as they die, and new ones formed to take their places, a condition would soon arise which would cause stagnation. Disuse of the reproductive system does not render males infertile. I have examined the semen for live sperm in dogs which have mated for the first time, at the age of nine months, at the age of two years, five years, and one that was nine years old and I could find no instance in which the sperm were not as active as they are in the frequently used stud dogs. Also the amount of semen seemed fully as great.

While it is impossible to record the number of sperm that are discharged at a single mating, it would seem safe to say that there are seldom less than 200,000, and one authority estimates it to be several millions in the case of most species of mammals, and up to 200,000,000 in the case of a healthy man.

In each testile there are seven or eight hundred linear feet of tubules in which the sperm are manufactured. Thus a normal man has on the average fifteen hundred feet. It is safe to figure that during his lifetime a man may produce in excess of 300 billions of sperm.

When some of the semen is put on a glass microscope slide in a layer much thinner than tissue paper, and one part is observed which is about as large as a cross section of a small needle, one can see from five to fifty or more. That sample,

of course, is a very tiny sample of the whole, and yet any one of the thousands, if it were to reach an egg, would fertilize it. Nature is very lavish with the sperm and very frugal with the ova.

The sperm will live for some little time if kept warm and in darkness. I have killed dog's sperm by exposure to the

Looking through a high-powered microscope one sees a spot about as large as the cross section of a small needle. Here is how dog sperm appear in such a field.

sunlight for one minute or less. But I have also seen them live for quite some time under more favorable conditions.

Among monogamous animals, the two pair off, and at the proper time they mate. It is not known how many times they will mate during a season, but it is believed on good authority that the act occurs only a few times. It is no doubt a frequent occurrence that a male goes mateless during many seasons. If he were not ready on all occasions it is conceivable that the species would die out in short order.

Among herd animals, there are many males which do not have an opportunity to mate for several years, being dominated by the herd leader. Some mate around the outside of the herd, but in the majority of cases the herd leader takes care of the females. Under such conditions, it is easily seen that there is need of periods of long inactivity of the sex organs, and this is provided for in all animals, including human beings.

Members of the dog family are the only animals known to science which, when they mate, remain attached to each other. This is accomplished by a swelling of the penis to very large proportions, especially at the rear. The spongy tissue becomes filled with blood, which prevents withdrawal of the penis until the blood has subsided. This happens involuntarily. The "tying" is accomplished by the male, and the female has little or no part to play in it, which is contrary to common belief. The average length of time for many matings which I observed was eighteen minutes.

The outlet from the bladder and the vas pass into the prostate gland, and within it the vas and the tube which conveys the urine to the penis, combine. A sphincter muscle within the prostate gland serves as a valve allowing the animal to close the stream from the bladder more or less at will.

This is a much more important accessory to the dog family than to almost any other animal, as urine placed on a post or tree is the wolf's or fox's means of detecting the other wolves and foxes which have been in the neighborhood. The smelling post is a common thing and well known to all trappers. The yellow color of the urine is caused by the broken down red blood corpuscles being ejected through the kidneys and thus they are passed out of the body. No doubt there is a characteristic odor from each dog, which the other dogs with their wonderful powers of scenting, can recognize.

Depositing urine on bushes and along the road of a dog's travel is a help to him in finding his way home if he returns after the scent from his foot tracks has entirely evaporated. The sphincter muscle furnishes his control over his urine, and it is therefore very important to the dog. With other animals this is less important.

From the prostate gland runs the tube which carries either the urine or the semen. Thus another function of the prostate is to act as a valve to shut off the urine or the semen. Urine is acid. Semen is very alkaline. A small quantity of urine will kill the sperm instantly.

The vagina of the female during the mating cycle is kept in an alkaline condition by the discharge from the end of the uterus (cervix) and the vagina. But the external part of the vagina, from the point where the tube which conveys the urine (urethra) empties, is very likely to be in an acid condition due to the discharge of the urine. This is neutralized

by the discharge of the alkaline substance from the male, so that no acidity may reach the vagina proper. Some animals require greater quantities of this substance than others.

Above the vagina the uterus is alkaline. There must be this neutralizing process which will premit the sperm to live. If you have ever noticed that just as mating occurs a colorless liquid is emitted by the male you know the secret of the neutralizing agent.

First we must realize that the tube all the way from the prostate to the external world has been used by the male as a conveyer of urine. Naturally it might be expected to be very acid. The male, therefore, must secrete a liquid that will remove the acid condition in order that the sperm may live. Thus when the sperm are ejaculated, they pass continually through an alkalined tube.

In many animals including the human, just in back of the prostate gland, there are two ducts which attach to the vas, that is, one to each vas. These are known as the seminal vesicles, or semen receptacles. Formerly, it was thought that, as the sperm are manufactured they worked up to these storage reservoirs and remained there until they were absorbed. This has recently been disproved. There is simply semen with no sperm in these reservoirs. When ejaculation takes place, there is a goodly discharge of material which no doubt helps to draw sperm up the tubes to be discharged with the semen.

In the hog and dog there are no such storage reservoirs. Between the prostate gland and above the tube there is a large muscle. Through this muscle the blood flows in veins on its return from the penis. Now this muscle is a very important accessory to the reproductive system, for it is the muscle that controls the erection of the penis. When the muscle receives a certain stimulus from the brain, it contracts. An artery runs to the penis without passing through the muscle, but the veins pass through it on their journey back to the heart. The muscle therefore shuts off the veins. The blood can flow into the penis but not so much can flow out. Most of the blood, therefore, which has gone into the penis must stay there until the retraction of the muscle. In almost all animals retraction takes place at once after the emission of the semen. This is because of the fact that there is plenty of semen in readiness which is emitted in a short space of time.

But with some animals like the hog and dog, which do not have the ability to store semen near the prostate, there must be some sort of arrangement so that he will have time to eject sufficient semen into the sow or the bitch. The hog accomplishes this by long copulation but with the dog family this is accomplished by the muscle, which does not retract for some time—usually for ten minutes, and often not for forty-five.

As animals copulate there is a contraction of the vas which shortens it, and then a retraction which lengthens it, also there is thought to be a contraction of the muscles along the path, and a wave-like motion in the vas (peristaltic waves) so that a pumping effect is created. This draws the sperm which are contained in a colorless liquid along the tube until they reach the vagina of the female.

During the act of mating, there is considerable tension in the muscles of the whole reproductive system. This is also accompanied by a contraction about the testicle, which no doubt does its part in forcing the semen along the vas, and there is also increased blood pressure in the testicle.

In the case of the hog and dog families the long copulation and the tying allows plenty of semen to pass from the male to the female. It was thought that with the dog the tying was for the purpose of insuring the paternity of the pups, but this is not the case. The fact that several dogs may be fathers of pups in the same litter is conclusive evidence that the tying does not insure the paternity of the pups.

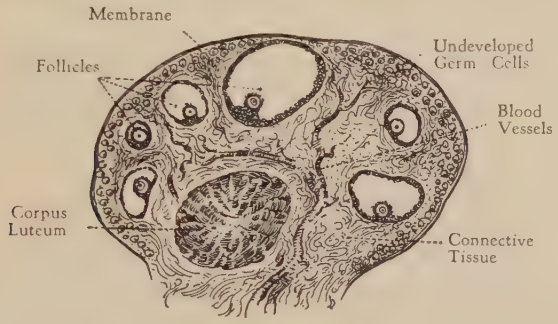
Frequently breeders have very set opinions as to the proper age at which it is advisable to mate young males for the first time. Early mating tends to make them excitable, and I always prefer to use a mature male. Mating immaturely makes him more excitable in the presence of females whether they are ready to mate or not. It tends to make him more anxious to be free from the confines of his paddock, pen, or run, and to make him notice every animal of the same species that passes. This nervousness may react upon him, slightly retarding his growth. But as to any actual harm which early mating has done, I have not as yet observed it. The male will not mate effectively until nature has made him ready. Then he is usually old enough not to be materially, if at all, harmed by it.

As to the frequency of mating, undoubtedly a male that is mated very often is not able to render as good service as the one used occasionally. We must remember, however, that there are almost always some sperm discharged. A normal service will probably contain at least 1,000,000 or more. A poor service, from a frequently mated male will contain several thousand at least. We have seen that there is actual need for a very small proportion of these, and that all except a small number go to waste at each mating. If a hundred succeed in reaching the ovary or upper parts of the tubes, that ought to be more than enough to insure pregnancy.

CHAPTER XVIII

THE FEMALE REPRODUCTIVE SYSTEM

Of the female reproductive organs, let us start with the most fundamental of the parts to which the rest of the system is accessory the ovaries. The illustration shows the parts of the ovary accurately. To those of us who have studied human



A typical mature ovary.

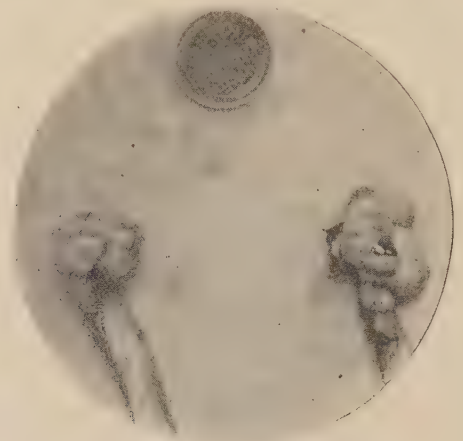
physiology it will appear that the other animals, while essentially similar, still show considerable difference, when we come to compare them.

In some there is usually but one embryo developed at a time. On this account the womb or uterus which surrounds the developing embryo must be capable of considerably more expansion and it must be much stronger than in the case of those in which a number of embryos are developed at once.

In some animals the uterus is of a double nature. The two horns or tubes take the place of the single uterus, and the part which corresponds to the single uterus is only that part which extends from the junction of the tubes to the cervix. In many animals such as the mare, cow, sow, ewe the ovaries are not enclosed in a sac; in the dog they are completely enclosed.

The average size dog's ovaries are about as large as a yellow-eye bean. They are proportionately larger or smaller, according to the size and age of the dog. To a casual observer, the ovaries might appear to be actually much larger, but we shall see the reason for that. Other animals have larger or smaller

ovaries in proportion to their size, the human ovary being about as large as the end of one's thumb.



A pair of dog ovaries with the surrounding sacs removed. This illustrates their appearance shortly after ovulation. The growths which cover the ovaries are the newly formed corpora lutea.

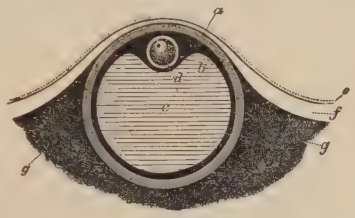
Within the ovary are the original germ cells which have developed in number until they are very numerous, but not nearly as numerous as in the testicle of the male. When the female becomes mature some of these cells begin to develop and enlarge, and a few in each ovary work to the surface as they are developing within sacs called the follicles which are filled with a fluid called the follicular hormone. The cells, which are the ova and their attachments, are just large enough to be seen with the naked eye. When the ova are completely formed, the sac will be about one sixteenth of an inch in diameter and of a bluish color, in animals of medium size.

As the follicles develop a change is also taking place in the reproductive system. It is especially becoming congested with blood.

The follicles reach a certain stage of development and then burst, liberating the ova. Usually there are some sperm waiting within the upper end of the fallopian tubes or in the sac surrounding the ovary in the case of the dog. As soon as the follicles burst and discharge the ova, the ova are at once beset by hundreds of sperm, which endeavor to pierce the wall and become a part of the cell, and thereby fertilize it.

As soon as an ovum has been entered by a sperm, the wall of the ovum becomes impervious to other sperm. In exceptional cases, more than one enters the same cell, but in this event, one dies while the other combines with the ova and a new animal is thus created.

There are also other changes which we shall consider later. The principal changes are those going on within the ovaries. The follicles which are growing are naturally getting closer to



A follicle ready to rupture. a—membrane of vesicle, b—granular membrane, c—cavity of follicle, d—ovum, e—surface of membrance, f—covering of albumen, g—tissue of ovary.

the surface of the ovaries as they grow. Each time there are hundreds of them, racing, as it were, for the surface. It is believed that certain chemicals are effective in increasing the congestion in the ovaries, and consequently of hastening the time when the follicles will burst.

Injections and doses of a chemical known as yohimbine are thought to help, but there has been no proof of this to date. Neither has it been scientifically demonstrated that it would produce a mating cycle to order, as some have claimed. Indeed it has been tried repeatedly and failed.

Copulation is necessary in some animals to produce ovulation. Those best informed believe that copulation advances the mating cycle appreciably once it has begun. Time alone will determine this, and several eminent men are now at work on it. The rabbit must copulate in order to ovulate at all, and perhaps it is so with one or two others, but certainly it is not necessary for the vast majority, irrespective of whether it accelerates the time at which the follicles burst or not.

The covering of the first follicles to reach the surface of the ovaries, finally becomes very thin. At that time dog follicles appear about as large as the head of a good sized pin, and purplish in color. Then those which are ready, become ruptured consecutively until in some animals twenty or more have burst. The largest number of ruptured follicles I have found

on dog ovaries was twenty-two. Some animals develop only one, as human beings, for instance. In about ten per cent of the instances, two are developed at once and if fertilized, twins will result, and in a very few cases, more than twins will be developed by the rupturing of as many follicles.

Curiously enough this twinning trait seems to run in families. Dr. Charles B. Davenport, who has made a more thorough study of this than any other person, believes that the male has something to do with the survival of the twins which are conceived. There is one woman in the central part of the United States who has given birth to forty-two children, of which only seventeen are alive. With a large number of embryos that start out as twins, only one develops to maturity, the other being partially or totally absorbed in the uterus. It is a very common occurrence for physicians to find a tiny undeveloped foetus along with the normal one, in the placenta.

No one knows why in some animals so many more follicles burst than in others, except that it is hereditary. It is possible to select for this trait and establish pure lines for it. I

A purebred bloodhound bitch which had fifteen vigorous puppies at her first litter.

can well remember that my guinea pigs, which I had as a boy, seldom had over three young per litter and many times only one or two. Now, one breeder with whom I am acquainted, who supplies hospitals, has had but few litters born which

contained less than four young, and frequently his guinea pigs produce six. He has developed them to this stage by selection.

As soon as all of the ripened follicles have burst and discharged their precious freight, a growth starts in each ruptured follicle which not only fills the cavity but protrudes and occupies a larger space than the follicle. This growth is known as the corpus luteum or luteal body, and this, as we shall see, is one of our keys to the mating cycle.

The discovery of this function and the developments which have come out of that knowledge bid fair to some day become one of the greatest boons to the man who owns a female which is likely to be made worthless for her use by coming in season during an inappropriate time. The knowledge may also be a boon to the owner of every female animal as we shall see when we study the mating cycle.

The luteal body or bodies develop very rapidly after the follicles have burst, and the cells which compose it are very large. There are many tiny blood vessels also, but the large yellow cells which prepare the secretion are the most rapidly growing cells within the body. While they remain, the cells within the ovary do not develop, and not until they have shrunken and almost disappeared do the next group of ova develop within their follicles.

The ova which are fertilized work downward in the tubes until they reach the uterus and become attached to it and there they stay and develop until they are ready to be born.

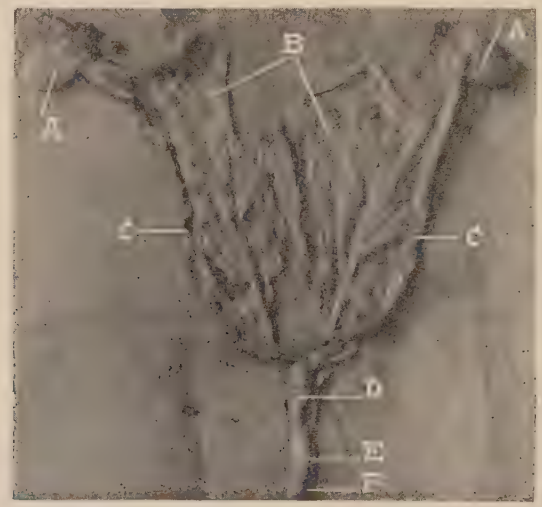
When mating takes place the sperm from the male work their way up the uterus and through the fallopian tubes. For many years the way they found their way up the tubes was a mystery. But now it is known that the sperm will always head in the direction of a current, and the movement of their tails propels them forward. To us they seem to move very slowly, but considering their minuteness they actually progress very rapidly. There is a continuous slight discharge in the tubes so the sperm keep pointed in the right direction by this current and their tails probably help to move them upward along the tubes. The greatest help, however, in arriving at their destination is the wavelike motion of the whole reproductive system. Beside their own ability to navigate they must have assistance, and this is given by the wavelike motion

of the reproductive organs which causes a pumping and thereby moves the sperm along.

The connection between dogs is closer than between any other animals. With most animals the semen is deposited directly into the vagina and but little discharged directly into the mouth of the uterus. In fact, as yet there is need for much research as to exactly what does happen when several kinds of animals mate.

The divisions of the uterus in animals which possess a divided uterus are more than mere tubes. A cross section shows that the wall during the mating cycle is exceedingly thick. This is the nest where the young stay before birth and therefore it must be capable of considerable stretching.

The illustration of the reproductive system of a bitch shows how the uterus appears when the ova have been fertilized but a week. The thickened places along the divisions are the de-



The reproductive system of a bitch in the mating cycle. A—ovaries, within sacs, B—connective membrane, C—divisions of womb or uterus, D—body of uterus, E—cervix, F—vagina.

veloping pups. Of course at they grow to a size large enough for birth they will be in very close proximity to each other. The reproductive system of the sow is essentially like that of the bitch.

In a very general way the number of teats is an indication of the size of litters which a breed produces. The cow, horse,

and sheep have but two to four teats and produce one or two young; all of the animals which have a double row of teats on the abdomen produce litters. The guinea pig is an exception, having but two teats and producing one to six young. The species and breeds which uniformly produce large litters are those which have the most teats. Among dogs, the Great Danes and bloodhounds have an unsually large number, while the lap dogs seem to have fewest. But no one can truthfully say that the number of teats which develop most fully before the birth of the litter is any indication of the number of young in the uterus. The reasons that some teats do not develop are not completely known. Injuries to the breast frequently render sections useless. Caked breasts also are a frequent cause, making a fever within the breats and causing the destruction of the cells, so that at the next pregnancy there is no development in that section.

CHAPTER XIX

THE MATING CYCLE

Pick up almost any book dealing with the physiology of reproduction of animals and you will see something about the oestrus cycle.

The Greek word oestrus means gad fly. Oestrus has also come to mean excitement, inspiration. Socrates said that he was a gad fly who went about urging people to do certain things. It seems to me that there is a better term to express this period than oestrus. Also the expression "heat" when applied to certain periods of female animals is a misnomer. Like the idea of blooded heredity it has come down through the years, because it was thought that at a certain time the female had a rise in temperature which made her desirous of copulation. Likewise the use of the word menses is wrong when applied to all animals because that would indicate a monthly periodicity, and we know that such is not the case with all.

We read about the oestrus cycle of the rat, the guinea pig, the rabbit, the cat, and here I am going to describe this same phenomena but I shall use the term *mating* cycle for it.

I believe that *mating cycle* is a more appropriate name because so far as external behavior is concerned, the mating is the crucial thing, and the internal behavior of the reproductive organs coordinates with it. Furthermore, for only a portion of the whole cycle, less than a third in fact, is the female willing to mate or anxious to mate, as the term oestrus would imply. So, as we are first going to study the phenomenon from the outside, we are therefore concerned with the time of mating and we shall then check that with the internal behavior.

The following table shows many facts of interest regarding reproductive phenomena of man and the major species of domestic animals.

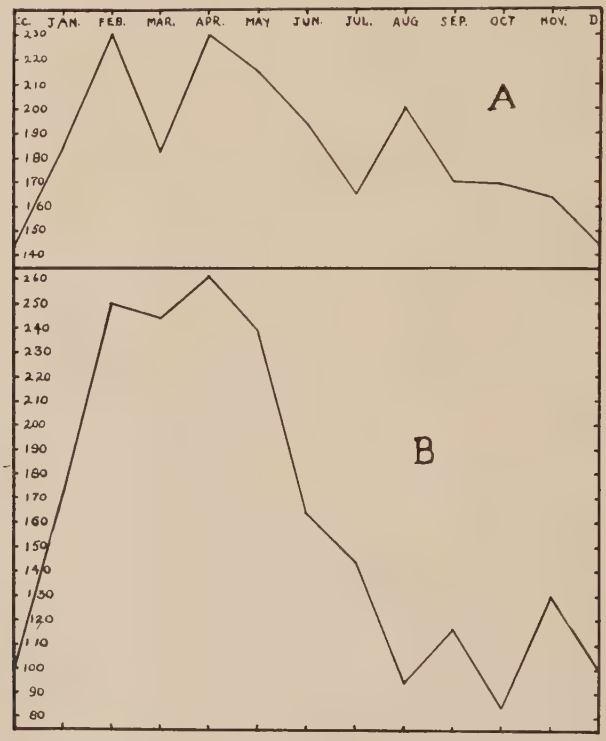
	Woman	Mare	Cow	Sow	Ewe	Bitch	
						large breeds	small breeds
Breeding season wild state		April to July	any time	Jan. to June	Sept. to † Dec.	Jan. Feb. Mar.	same
Breeding season under domestication	any time	any time	any time	any time	sometimes May also	any time see page 196	same
Normal Length of mating cycle if not mated	28 days	21 days	21 days	21 days	12 mos.	6 - 7 mos.	same
Duration Copulative Period		3 - 7 days	1 day	3 days	2 days	7 days	same
Duration of gestation	280 days	336 days	280 days	112 - 114 days	147 - 152 days	61 days	same
Age at puberty	Depends on race 10 - 15 years	10 - 12 mos.	5 - 6 mos.	3 - 5 mos.	4 - 5 mos.	10 - 14 mos.	7 - 9 mos.
Normal age for first mating	Puberty	2 years	9 mos.	6 mos.	7 mos.	10 - 14 mos.	7 - 9 mos.
Usual recommended age for first mating	*Depending on race 19 - 22	3 years	18 - 24 mos.	9 mos.	18 mos.	16 - 20 mos.	13 - 15 mos.
No. days after parturition to first copulation.		7 - 10 days	highly variable 3 wks. up	3-5 days after weaning pigs	next fall	4 - 8 mos.	4 - 5 mos.

*No one knows with certainty whether our present social system is best. Since it has been demonstrated that pregnancy is no harder for a young woman of 17 than for one of 25, it might be best if we had earlier marriage and the rearing of families of four or five high grade children to grow up with the parents.

†Dorset sheep frequently have a second season in the spring.

This table shows among other things that there are definite mating seasons for some animals while others have no specific time.

It was thought that the dog had no definite time and that about as many had their mating cycles at one time as at another. In order to learn the truth I prepared the curves shown below, based upon the birthdays of two different groups of dogs of two thousand each.



A shows the mating cycles of 2027 German Shepherds. B shows the same for 2000 foxhounds south of the Mason-Dixon line. The owners of both of these breeds want few fall litters and hence the absence of the expected peaks in the fall.

In both curves it will be noticed that there is no season of the year when there are no bitches ready to mate, but that in the case of the southern hounds, there are over three times as many in April as there are in October, or over two and one-half times as many in December, which is probably the lowest

point. Most bitches will mate twice a year. The fall or winter peaks are absent, because few breeders want fall litters and allow the bitches to go over.

We shall employ the term *cycle* because we are not alone interested in the part of the cycle when the female will actually mate, we are interested in the complete story of the internal and external happenings from before the day when the female by any means lets us know that her reproductive organs are preparing for the mating season, until that comes around again. That is the cycle.

Dogs are so typical of the mating cycle, and in a way stand as an average between all of the animals, and furthermore they can be and have been observed by almost everybody, that we shall employ them as an illustration of the mating cycle, just as we did for the hereditary basis of breeding. Fewer persons have been able to watch a sow's physical or mental behavior, or yet a guinea pig's, than have been able to observe the dog's. The dog furnishes common ground. In the next chapter the known mating cycles of several animals are given, and described.

It may be well to review the general physical changes here and to consider them later, in relation to the mental or psychologic happenings. With the average normal bitch the first sign that the mating season is approaching is the swelling of the vulva. This is generally accompanied by a considerable increase in appetite, a restlessness and frequently by an increased demonstration of affection. When the vulva has become about as large as it will swell, a bloody discharge begins. Sometimes this is very slight, and sometimes in larger quantities. There are some bitches which will drop no discharge at all during an entire cycle, and at the following cycle will flow freely. There are others that never flow at all. We shall consider this our starting point in this discussion. The first day of the discharge we shall call the first day of the cycle.

At first the vulva is firm and hard, but as the mating cycle progresses it becomes looser, until it is quite soft. Usually not until the condition has become soft, will the bitch mate.

Each day, the discharge becomes less and less dense red in color, until by about the ninth day the red color has almost entirely disappeared and the discharge is almost white, or cream colored. The change in color is caused by diminution in the percentage of the red blood corpuscles, as we shall see.

By the tenth day an average bitch will generally stand for the dog and a strange dog will usually attempt to mate with her. This mating period ordinarily continues for eight or nine days longer until at about the eighteenth day the bitch will not be as eager and by the twentieth she will fight the dog, and by that time the dog will make no attempt to mate with her.

I am speaking very generally from my own records. I might take instances like one of a foxhound bitch which would stand for any dog, beginning at the fifth day after she first showed signs of discharge and from then until the twenty-fifth day she would be willing to mate. That is the longest period of which I have any record. On the other hand, I mated one bitch on her tenth day, which was the first day she would stand, and by the 15th day she would have nothing more to do with a dog, despite the fact that she produced only one pup. Counting from the first show of bloody discharge the average length of the apparent mating cycle is eighteen to twenty days.

The whole cycle externally might be best described as occupying four stages.

First is the stage which includes the swelling of the vulva, the restlessness, and greater show of affection and increase in appetite.

The second stage is characterized by the bloody discharge from the vulva, with the gradual softening of the vulva, during which time she will not permit mating, and the restless disposition, which makes her want to run if she is not confined.

The third stage is the mating period proper.

The fourth stage might be said to be getting back to normal. It starts with the first day when the bitch growls at the dog and will mate only after considerable urging. This, of course, is considering that the bitch has not been mated. If she has been mated the vulva does not decrease as much in size, and other changes take place.

The first method employed of determining the mating cycle was by mating dogs on different days of the mating period proper and noting results. (The mating period is that portion of the mating cycle during which the bitch will permit copulation). These results were gauged by the size of the litters. In three instances, where the mating took place on the first day of the period, litters of only one puppy were obtained.

The first day was determined by allowing the male to make

persistent advances, until she would mate. This also corresponded with the tenth or eleventh days after the first bloody discharge was noted. The dogs used were of the following breeds: Doberman pinscher, Norwegian elkhound, a hybrid (Norwegian elkhound x hound). Another bitch when mated on the first day of the mating period, produced two pups. This was a foxhound, mated to her brother. One of the pups was born dead. In three cases no puppies were born as a result of first day mating. Each of these bitches produced good sized litters in subsequent matings.

In three instances when I mated bitches which had gone past the copulative period by two days, or what would be equivalent to the twentieth day on the diagram, on page 202, large litters were obtained. These were two black and tan foxhounds both of which were mated to foxhounds, and one small longhaired mongrel which was mated to a male hound. Each of the hounds produced eight pups and the mongrel produced seven.

In one instance a pointer was mated to four dogs of different breeds at different times and produced pups by all four.

In order to learn the true time of ovulation and at the same time discover the life of the sperm within the fallopian tubes of the bitch, if possible, bitches were obtained which were expected to begin the mating cycle within a short time, and other bitches which were in the bleeding stage. With the latter, I was able to judge the day of the mating cycle by determining the first day of the copulative period. These bitches were killed and the ovaries examined.

It is not necessary that a bitch copulate in order that the follicles may rupture. It is a common opinion among dog fanciers that copulation will shorten the cycle and this may be the case. Perhaps observations on greater numbers would show a definite advancement of ovulation, but all of my results would tend to show definitely that ovulation occurs at about the sixteenth day, or the fifth day of the copulative period.

There are always a great many more follicles to be seen on the surface of the ovaries than there are corpora lutea. They seem to be of all sizes, from barely visible, up to the head of a pin in size. Apparently there is a race for the surface of the ovaries and the follicles which are most developed, are the winners. Then corpora lutea develop and shut off the rupturing and subsequent growth of the remaining follicles. Sections of ovaries or dissected ovaries indicate this very clearly.

CHAPTER XX

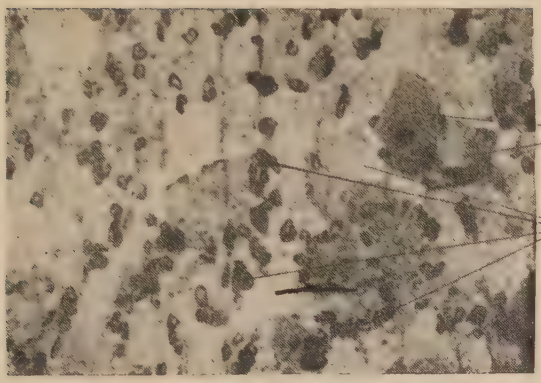
OTHER REPRODUCTIVE CONSIDERATIONS

Dr. George N. Papanicolaou deserves the credit for a discovery which was epoch-making in the sciences of biology and medicine. Experimenting with guinea pigs, he found by microscopic examinations of vaginal smears which were taken daily from these animals, that there was a very noticeable change in the numbers and kinds of cells which were discharged into the vagina. To the naked eye that discharge appears to be simply mucus, but under the microscope, if properly preserved and stained, it shows the most remarkable changes. There is a daily change in all animals during their mating cycles, and the change is definitely cycular. Every stage of the cycle has a characteristic smear. Therefore Dr. Papanicolaou could tell by examining the smear, just what day of the cycle the guinea pig was in. But further than that, he could also distinguish easily whether the guinea pig was pregnant or not, because pregnancy also has a characteristic smear.

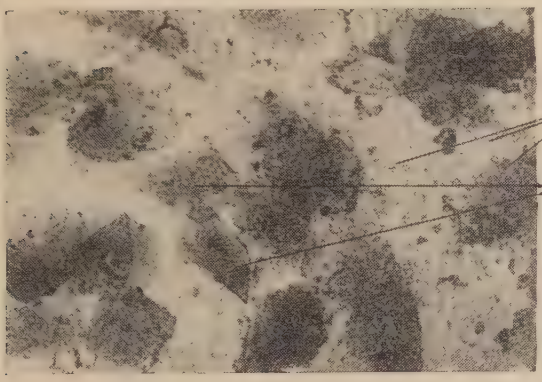
Then he applied this discovery to other animals, including human beings, with great results. Some scientists have spoken of his discoveries as being on a plane with those of Pasteur, and I believe that time will prove their assertions to be correct.

Dr. Papanicolaou showed me his method and helped me to apply it to dogs so that I was able to learn to do it for them, and I believe that any breeder after a brief study of the cells of the body, and the acquisition of a microscope and ability to recognize the different kinds of cells in the reproductive system, can readily learn to do the same. More than that, this discovery will be made applicable to all kinds of animals so that the day will soon be here when this new method of diagnosis will be made universal in its application. The illustrations give the reader an idea of the difference of the smears during each of three stages of the mating cycle.

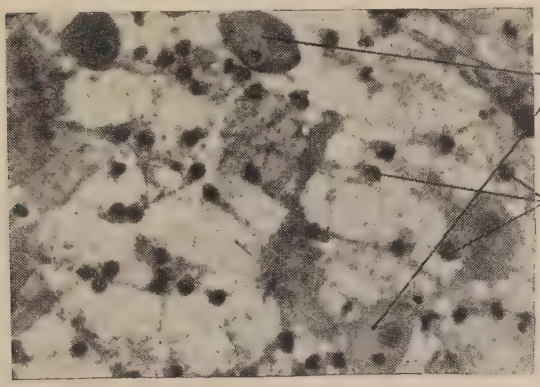
The smears were stained with eosin and haematoxlin. They indicate very clearly a change in the kinds, quantities, and amounts of cells. There are three definite periods, and these are typified by the photographs in the illustration. The first stage is a bleeding stage, which is of course characterized by



1. THE BLEEDING PERIOD



2. THE MATING PERIOD

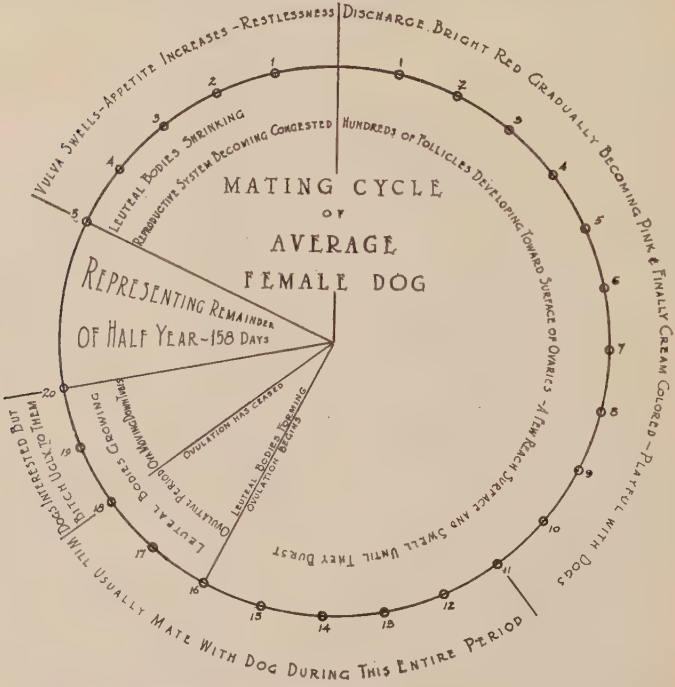


3. THE POST-MATING PERIOD

an excess of red blood corpuscles (erythrocytes). In some bitches there is a general sprinkling of these cells throughout the whole period, in others there are very few beyond the bleeding period.

A distinct copulative period, lasting six to seven days is characterized by an excess of cornified cells. At about the sixteenth day this stage gives way to another characterized by the presence of deeper vaginal cells and many leucocytes.

The dog has a long period of rest between mating cycles. It was thought for years that this period of inactivity was characterized internally by no change in the ovaries. Determination of this phenomena by the smear method was a very delicate task, but Doctor Papanicolaou studied hundreds of smears and was able to report that there is a definite periodici-



ty of change within the ovaries going on all the time irrespective of weather the bitch shows it by outward signs. Often the dog fancier notices times during the inactive period when

males are more attracted to the bitch than at other times. Some bitches exhibit this tendency more than others. Just what converts one of these periods into the active period which is characterized by all the outward symptoms and the copulative period no one knows as yet.

The sheep, and the horse to a certain extent, exhibit the same phenomena, but no one has yet studied the mating cycles or other particulars necessary to be known before we can understand whether the same thing is going on within their ovaries. The fox and the raccoon, and other furbearers no doubt have the same periodicity, which will one day be determined and no doubt when the cause of the true mating cycle is known, it will be made the basis for the regulation of the mating cycles at the will of the breeder.

THE LIFE OF THE SPERM

As I have already mentioned, the ovaries of the bitch are in a sac. Each sac contains a few small drops of a serous fluid. The sperm must migrate up the uterus to this sac. With most animals there is no sac surrounding the ovaries, and it is believed that fertilization takes place in the upper ends of the fallopian tubes.

Thus far I have found no sperm alive over three days old. At two and a half, there were plenty of live sperm and at three days there were plenty but they seemed to have no motion. Possibly the technique was faulty, but being as careful as possible, I found live ones at times, at other times none at all, and occasionally partly disintegrated sperm. Together with the results obtained by mating early in the copulative period, it seems logical to conclude that the sperm do not live much over four days, if that long.

There is very little difference in the various breeds of dogs with regard to the age at which the first mating cycle begins. The giant breeds are a little older on the whole, but there is not so great a difference as was commonly supposed. The duration of the mating cycle is practically the same, being entirely independent of size.

As a result of my study of the mating cycle of the dog I was able to prepare the foregoing diagram which is submitted as a picture of the whole cycle and may be of practical help to any breeder of dogs. In the next chapter is presented the latest information on the subject of the reproductive phenom-

ena in other animals. As the idea of representing the cycle in a circle is original with me, I shall make the same application for each animal for which the mating cycle is definitely known. The description of the external happenings appears on the outside of the circle, and those of the internal on the inside of the circle. As will be seen, my studies indicate that the best time to mate dogs for large litters is toward the end of the copulative period, certainly after the second day counting from the time when the bitch will first accept the dog, or the thirteenth day on the average, after the first red discharge appears.

The phenomena by stages, inside and out, in the bitch are described in the following paragraphs. And for other animals the principle is the same with variations, depending on many things. The time occupied may be longer or shorter, there may be no appreciable discharge from the vulva, but in the main all animals are alike.

FIRST STAGE. Duration: three to five days.

External

Actions: Increase in appetite, restlessness, more demonstrative and affectionate.

Physiological: swelling of the vulva and frequently a slight fullness of the breasts appears. Male dogs will begin to pay attention to the bitch.

Internal

The luteal bodies are shrinking rapidly and are now reduced to a pinhead in size. The surface of the ovary is smooth and looks about as a yellow-eye bean in size and proportion. The Fallopian tubes swell to a considerable size and remain so during the whole mating cycle.

SECOND STAGE. Duration: nine to twelve days.

External

Actions: Restlessness, disposition to urinate frequently, and to roam further from home, also to associate more with male dogs; dogs attracted to the vicinity if she has been allowed her freedom; exhibits considerable playfulness.

Physiological: Vulva gradually softens and discharge commences and continues throughout the period, starting as a bright red, and gradually becoming lighter in color. By the end of this period the vulva has become soft and the discharge is a cream color and much thicker in consistency than at the beginning of the period.

Internal

The surface of the ovaries continues to be smooth. The luteal bodies have disappeared and the ova are growing within their folli-

cles rather deep down in the ovaries. The character of the cells discharged into the vagina by the reproductive system continues about the same except that the number of red blood corpuscles diminishes gradually.

THIRD STAGE. Duration: six to eleven days.

External

Discharge usually ceases. At the beginning of this stage the bitch is generally very playful but she will stand for the dog. This willingness continues until toward the end when the bitch often becomes frantic for the companionship of a dog and will do her utmost to become free from her confinement. At the end of the stage, she will sometimes come out of it suddenly, and turn very ugly toward any dog which approaches. Sometimes this ugliness will change to willingness for mating. Usually, however, the change in manner is gradual, occupying about twenty-four hours.

Internal

The follicles are continually growing. At first they may be seen on the surface of the ovary as tiny spots. As the period wears along the spots become bluish and larger until they are slightly above the surface of the ovary. At about the sixteenth or seventeenth day they have grown so large, the membrane over the top has become greatly stretched, and the pressure on the inside has become so great that the membrane ruptures and the liquid (follicular hormone) and the ova which they contain are discharged into the sac surrounding the ovary. From first to last this may occur within a short time, say a few hours, or it may occupy two days. When the follicles have ruptured the membrane heals, then within the follicle some new cells begin to grow very rapidly. These are the corpora luteal bodies. They eventually grow until they are about as large as peas. By the time they are half grown they discharge enough of a chemical (luteal hormone), which they manufacture into the blood of the bitch that the effect upon her actions is very remarkable. It is this hormone which causes her apparent antipathy for the dogs. This stage ends when the luteal bodies are about half grown.

FOURTH STAGE.

External

If mating has not occurred, the vulva shrinks to its normal size rather quickly. If mating has occurred and pregnancy resulted, the vulva will not reduce in size as quickly, and the breasts and teats will not usually reduce, but very gradually increase in size. The bitch will have nothing more to do with dogs and the actions are mutual, the dogs paying no attention to her once they have assured themselves that she is no longer willing to mate.

Internal

The luteal bodies grow to full size and this acts as a check on the desire for mating: the tubes reduce in size to normal. The ova work down the tubes slowly moving in the gradual discharge which

is always working its way down the tubes. It is several days after they are discharged from the ovaries before they have decomposed. Therefore forced mating a few days after the bitch first refuses the dog is frequently productive of litters of pups.

In case mating occurred and the bitch is pregnant, the tubes continue to enlarge rather than shrink as the pups develop.

THE GESTATION PERIOD

The gestation period is the time occupied by the young in developing from the time of conception until birth. This is generally considered to be sixty-three days in the dog. But is it? I believe that it is sixty-one. I have found that the average bitch is mated about two to three days *before the ovulation occurs.* Therefore we should say that gestation has been miscalculated. The sixty-three days is the time occupied from the time of *mating* to the birth of the pups. Actually the sperm have lived and awaited the ovulation of the ova and then fertilized them. Not until that time does pregnancy begin. So if the average of all births is sixty-three days after mating, and the average mating has been two or three days prior to ovulation, then the gestation period is properly sixty-one days rather than sixty-three.

THE OVARIAN HORMONES

If you have read the preceding paragraphs carefully, and appreciated the significance of them, I can almost hear you formulating a question. You wonder if it is true, that a chemical introduced into the blood by the luteal bodies causes the female to terminate her mating cycle, and if another, the follicular hormone, causes her to begin her mating cycle, then why would not the same result be accomplished by artificially injecting these chemicals into the blood? Suppose that they could be procured in large quantities from the ovaries of animals in the great packing establishments, where they remove quantities of ovaries from cows, hogs, sheep and goats, it would seem easy to secure goodly amounts of both kinds of hormones.

Now as a matter of fact it is a relatively easy matter to do this. The large manufacturers of glandular substances obtain

glands from the packing houses. The ovaries, of course, are glands. The chemist can extract the hormones from them and properly prepare them so they will be extremely useful to animal breeders. Several investigators are at present working out the proper dilutions and in the future both of these

The effect of the lack of secretions of the sex glands is well illustrated above. The spayed hen and the caponized rooster grow to look alike. The hen grows hackle feathers and spurs; the capon develops no comb and wattles.

hormones will be put on the market so that all animal breeders may obtain them. It has been my pleasure to cooperate in this work.

The Follicular Hormone

The follicular hormone will be useful in regulating irregular females. It will be used to bring a whole kennel of dogs into their mating cycles all within a few weeks. I believe the ovarian hormones will be especially used in the large kennels in the future. Also for cattle, sheep and swine it will find a use to a lesser extent. But even with these animals we may see it profitably used. In some sections two lambings a year would be very profitable from a ewe, instead of only one.

Probably one of the most valuable uses for the follicular hormone will be in connection with breeding of the fur-bearing animals. The fox farms have now become large enterprises. There was a time when one did not think much about the business of fur farming. Today when a pair of fine foxes may cost $1000 or over and their pups are worth several hundred dollars apiece, it is to the advantage of the fox farmer to see that his females do not skip a year of breeding because they are in season only once a year. If in the event that they should miss, it will be a simple matter to bring them into a

cycle by the injection of the follicular hormone. But what is perhaps even more important, it will probably be possible to raise two litters a year by injection in the summer. There is a possibility that the material will revolutionize the fur farming industry.

The objector will say that this is not natural, that nature intended that the young should be born in the spring, and make other such claims. Granted, but is not the whole fur breeding industry unnatural? Why, for instance, should the fur farmer object if he can raise two litters, even though he has to keep one of the litters until the next winter before he kills them? He would feel sure that he had some good large animals ready for breeding or for fur. The same argument applies to other furbearing animals.

The Luteal Hormone

So much for the follicular hormone. Now what about the effect of the chemical which is secreted by the luteal bodies? It has been made to effectively postpone the cycle. But at present it is not properly standardized. By the time you read this, chemists may have learned a way of incorporating the hormone so that it is 100 per cent effective. If it is injected when a female is expected to begin her cycle, the cycle may be postponed until the effect of the hormone is gone.

It is highly interesting to realize that in all animals the chemical composition of these hormones is similar. The fact that the hormone secreted by a cow will accomplish the same purpose when used in a human, a sow, a ewe or a bitch certainly shows the close interrelatedness of all the animals, including mankind.

CHAPTER XXI

REPRODUCTIVE PHENOMENA OF MAN AND VARIOUS ANIMALS

We have taken the dog as the subject of an extensive and intensive study of reproductive phenomena. In this chapter we shall drop the dog as an illustration, and give our attention to other animals. It will become apparent how close is the resemblance between all species, where much is known about their reproductive mechanism and behavior.

In all cases the behavior is largely the result of hormones which affect the whole organism. All animals from the elephant to the mouse are motivated by a similar impulse which is caused by hormones secreted by the ovaries, and perhaps by the secretions of other glands which are affected by the ovaries. The fact that the removal of the ovaries causes a cessation of all such manifestations, proves that the ovaries and their secretions are the cause of sexual behavior and physiologic changes.

While we are considering the facts which are common to all animals, we must admit that there is at present a great gulf in our knowledge, namely just why those animals which do not have frequent cycles, and those which at certain seasons of the year mate, although they exhibit a frequent periodicity (like the horse), begin their mating cycles or mate at certain times of the year.

The horse under artificial conditions will breed at any season, but under natural conditions will breed only in the spring and fall.

There are seasons when more animals of a certain species mate than at others What is the reason? The breeding season of wolves, foxes and raccoons comes *during* the cold weather. With horses, the normal season comes just *after* the cold weather. Sheep normally breed in the late fall, with the *approach* of cold weather. Swine on the other hand breed more when cold weather is *receding*. Temperature therefore has but little to do with it.

Shedding of the coat has been thought to have some influence but at best this is a secondary manifestation. No doubt the coat is shed because of some other condition which is toning up the system: Horses, cattle and some of the smaller animals shed in the spring as the warm weather is approach-

ing, but some of the other animals which also shed at this time, have their mating cycles at other seasons.

It is worth while for us to remember that several animals which mate but once a year, do so just after the coat has been shed and replaced, or at a time about six months later. In other words nature has endeavored to have the whole system in the best physical condition before the mating cycle begins, but it takes more than excellent condition to induce a mating cycle at any time. The person who lifts the veil to this perplexing question will render a great service.

In most respects the basic principle is the same for all animals. irrespective of when they mate, how many young are born in a litter, or any other consideration. Let us now inspect those which are known, beginning with fowls. The reproductive mechanism is quite well known for the great majority of animals, but the mating cycle has been studied in the cases of but a few. With the introduction of the smear method this diagnosis becomes simpler. Now, what is necessary to be done in order to determine a cycle, is to take several sets of smears from different females, over an extended period. Then a certain number of animals must be destroyed or spayed to observe the condition of the ovaries and reproductive system.

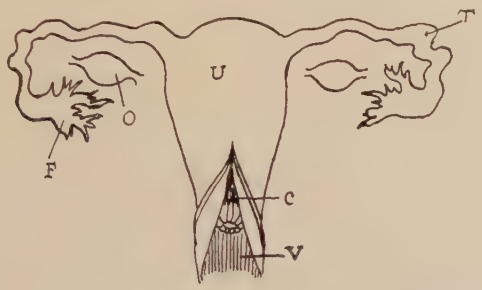
With these findings must be correlated the outward physiologic changes, and the actions, and the story is told, or at least enough of it to be of the greatest assistance to the breeder of the kind of animal under consideration.

By the old methods it was necessary to destroy great numbers of animals or else visit the slaughter houses and obtain reproductive organs in all stages of the mating cycle. The smear method is so practical that it may eventually become a major method of diagnosing many conditions of the reproductive organs, the proper time to mate, the cause of barrenness, whether or not an animal is pregnant—and the study is just in its toddling infancy.

In considering each of the following it should be remembered that the mating cycles are given as they are, on the assumption that mating does not occur and that pregnancy does not begin. If pregnancy begins then the liklihood is that it starts close to the time of ovulation, because in general, mating takes place preceeding this time and the sperm are waiting to fertilize the ova close to the place where the ova enter the fallopian tubes, if not in the upper part of the tubes themselves.

REPRODUCTION IN MAN

The illustration above shows the pricipal parts of the female reproductive tract. One of the ovaries, at the proper time discharges an ovum. This is picked up by the fimbrae attached to the end of the fallopian tube. It is there that fertilization takes place, if the sperm have migrated up the tubes. A fertilized ovum decends the tubes and attaches itself to the



The human female reproductive system. c—cervix, f—fimbrae, o—ovaries, t—fallopian tubes, u—uterus.

uterus, where it grows, getting its nourishment through the placenta. In the great majority of cases fertilization does not occur and under those circumstances it is not known whether the ovum is resorbed or is discharged through the uterus.

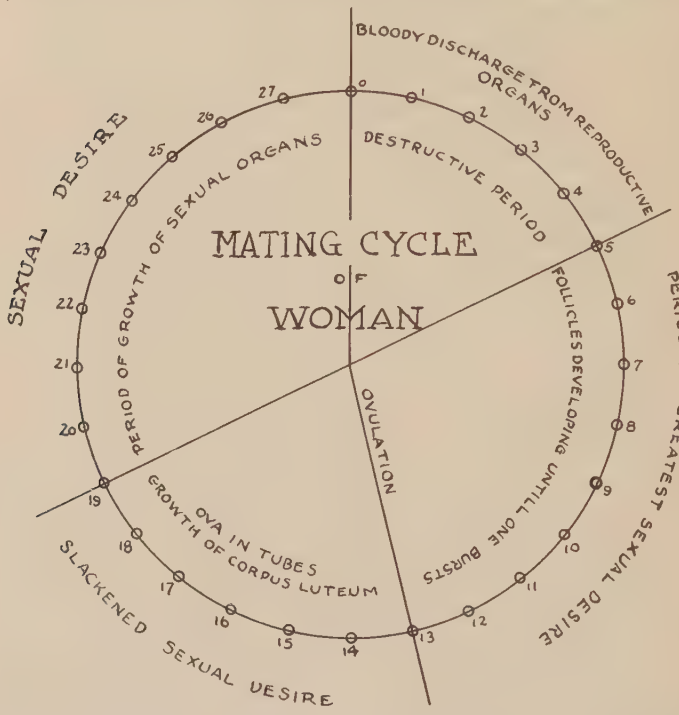
The uterus is single with no bifurcations as in the case of many animals. It is not known whether the semen enters the uterus at the time of copulation or whether the sperm migrate up the uterus by some suction created, or by their own efforts. It is the opinion of many experts that semen is not deposited further than the mouth of the uterus. The construction makes this unlikely. Probably the semen is deposited in the vagina, and the end of the uterus (cervix) dips into this and thus the sperm find a continuous passage up the tubes.

In case fertilization does not occur in the tubes it is believed that it may occur in the uterus if the ovum meets sperm there, but this has not been scientifically proved.

As to the life of the sperm in the female reproductive organs, opinions differ, but in general the estimates range from thirty six hours to six days.

MATING CYCLE OF THE HUMAN

Unlike the lower animals the external behavior of the human female does not correspond, apparently, to a definite cycular change in the reproductive organs. But the human



also differs from the other animals in having a brain capable of thought of a high order, and also possessing imagination. Thus the human is able to overpower the effects of the sex hormones, and while the mind is conscious the effect apparently produces the conclusion that the human animal is not subject to the same laws as the lower animals. If the observer notes the reaction when the conscious mind is off duty, and the person is drowsy, a different conclusion would be reached, for then the periods caused by the internal organs produce a result much more in keeping with the expectations. Certainly the early development of the corpus luteum shuts off sexual desire to a considerable degree.

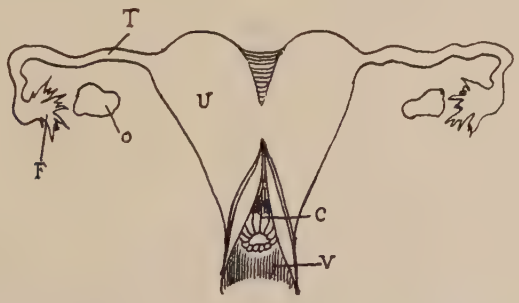
If we consider the onset of menstruation as our starting point, we begin with the destructive period. There is a tearing down of the entire lining, and the size of the reproductive organs is decreased. When this is done there is a rapid development of the follicles until one bursts. Immediately a corpus luteum forms and lasts for some little time. Less apparent lutea also develop within the small follicles which do not burst.

It is not known how long an ovum takes to descend a tube, but estimates range from three to eight days. With the growth of the corpus luteum there is a development of the whole reproductive system just as if there were an ovum nested and growing. If no fertilized ovum is present the growth stops and with the beginning of menstruation the system is reduced to normal size.

Everything considered therefore it is now believed that the most opportune time for copulation to insure pregnancy is during that period which corresponds to the mating period in animals, namely a few days or possibly a week before the day of ovulation, and then a few days following while the ovum is still in the tubes. Careful statistics indicate that cases are rare where pregnancy followed copulation after the nineteenth day and up to about the sixth.

REPRODUCTION IN CATTLE

The ovaries of the cow produce but one ovum at a time and for that reason but one fresh corpus luteum is usually to be



The reproductive system of the cow. c—cervix, f—fimbrae, o-ovaries, t—fallopian tubes, u—uterus.

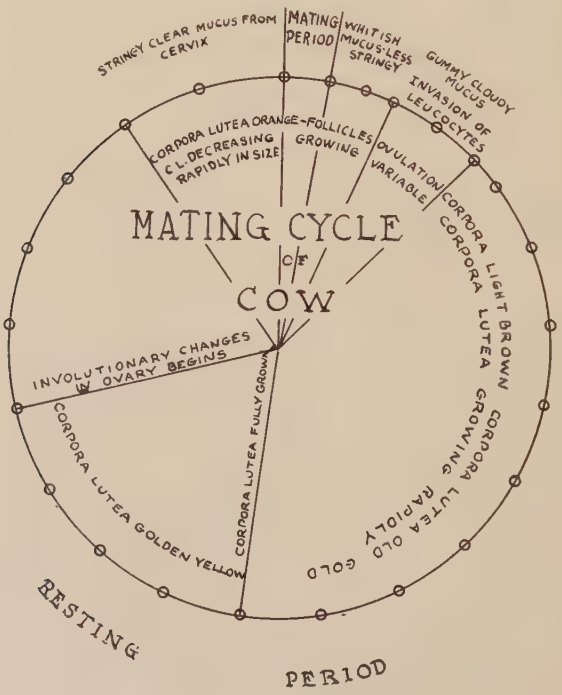
found on the ovaries, except in the case of the production of twins. As in the human the fimbrae take up the ovum and it then moves down the tube to the uterus. Probably fertili-

zation occurs in the upper end of the tubes, but it may also take place in the uterus. As yet no one knows.

The vagina is long, and the semen is deposited therein, from where some of the sperm work their way into the uterus and thence through the uterus and up the tubes.

The fact that mating takes place before the rupture of the follicle, seems to point to the conclusion that sperm may have found their way with the help of the wavelike motion of the tubes, up to the very top and perhaps in the fimbrae.

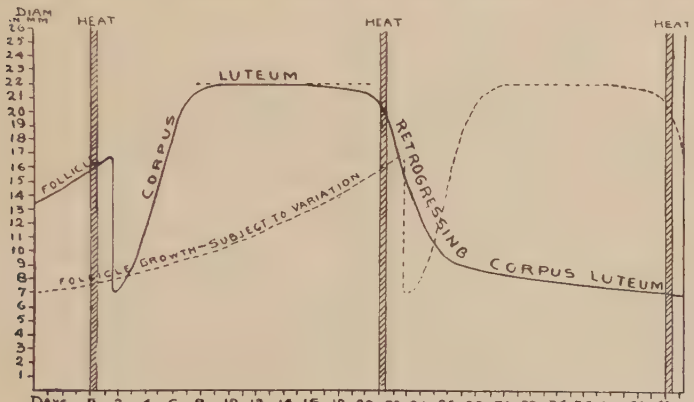
The uterus of the cow is double, and the walls are heavy. The fallopian tubes are rather small, and one leads into each horn of the uterus. The calf is developed in one of the horns. Naturally therefore it must be of a different construction than that of animals where many young are developed at once. It is also different from the human in being double.



THE MATING CYCLE OF THE COW

If we consider the start of the mating period to be the first day of the cycle, we find that the mating period proper occupies a half day or less. Ovulation follows the cessation of the mating period and may occur at any time from 30 to 65 hours after the beginning of the mating period.

Just before the mating period there is a clear stringy mucous discharge from the cervix. As the period progresses this becomes whitish and less stringy. Then there are a great number of leucocytes discharged through the wall of the vagina and the genital tract and this makes the discharge



(From McNutt)

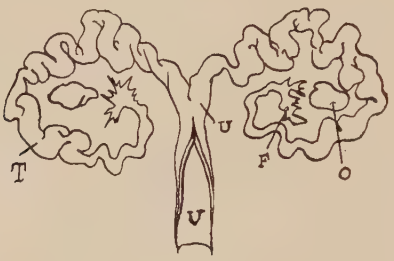
gummy and cloudy. In some cases there is a discharge of red blood corpuscles together with the usual discharge of the horns and uterus into the vagina which gives it a red color. This occurs about the time of ovulation.

Immediately upon ovulation the corpus luteum begins to grow and becomes functional. By the tenth or eleventh day it has attained its full growth. It becomes harder to the touch until the fifteenth day when it begins to change, and by the nineteenth day it decreases very rapidly in size, while the follicles grow until finally one bursts. The corpus luteum does not disappear for some time but remains in a small and inactive condition.

The color of the corpus luteum at the different stages is shown in the diagram on the opposite page.

REPRODUCTION IN SWINE

The reproductive mechanism of the sow is very similar to that of the bitch which we have already studied. The principle difference is that the ovaries are not enclosed within a capsule as in the case of the bitch. The ova must be discharged from the ovaries and find their way to the fimbrae, and thence down the fallopian tubes. It is probable that sperm are waiting in the fimbrae or the upper part of the



The reproductive system of the sow. c—cervix, f—fimbrae, o—ovaries, t—fallopian tubes, u—uterus.

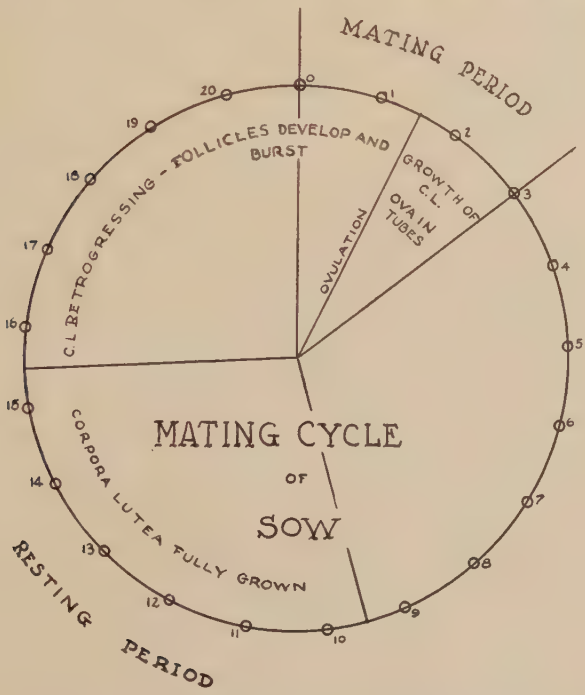
fallopian tubes. The ova upon being fertilized move down the tubes to the horns of the uterus and there attach themselves, and develop until birth.

The uterus is of a double nature having a very small body, in contrast to the human, and long horns or bifurcations in which the pigs are developed. The horns are larger in proportion than in any other animal, to accommodate the great number of pigs which are often born.

The number of ova developed at a time is not known, but has been estimated to be in excess of the usual number of pigs born. Since sows sometimes farrow twenty or more pigs and since fifteen is a common number, a goodly quantity of ova must be liberated during each mating cycle. The luteal bodies grow very rapidly and their secretion quickly terminates the mating period which, as will be seen on the next page is short, anyway.

MATING CYCLE OF THE SOW

As will be seen in the above diagram, the cycle commences with the first day of the mating period. The ova are developing within the follicles. A large number of these follicles are growing as rapidly as possible toward the surface, and they continue to do so until a number of them have developed so

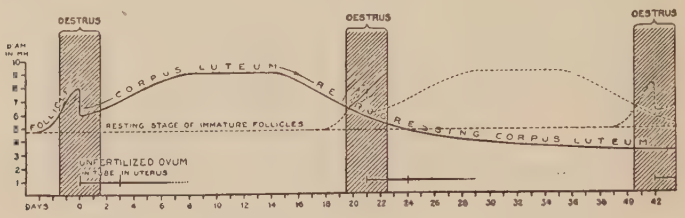


much that they have burst, probably from the pressure within. This occurs during, or about the middle of the mating period.

With the development of the follicles goes the increase of the follicular hormone which in turn changes the behavior of the sow, so much so that she will stand for the boar. The copulative period lasts for about three days and is terminated by the sudden growth of the corpora lutea, and the secretion of the hormone which shuts off all sex activity.

The length of life of the sperm has been estimated to be short, no live sperm having been found in the tubes more

than forty hours after copulation. In the case of sows which were bred by force after the termination of the mating period, no pregnancies resulted where the service took place more than one day following the end of the mating period. The corpora lutea persist through the following period in a slowly degenerating form.



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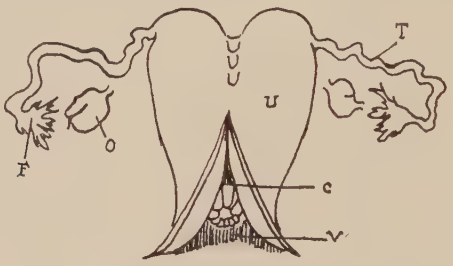
REPRODUCTION IN HORSES

Unfortunately, the horse has not yet been studied to determine the mating cycle. We know but little about the internal behavior, but sufficient to help materially in overcoming problems of sterility. As will be seen, the uterus is double in

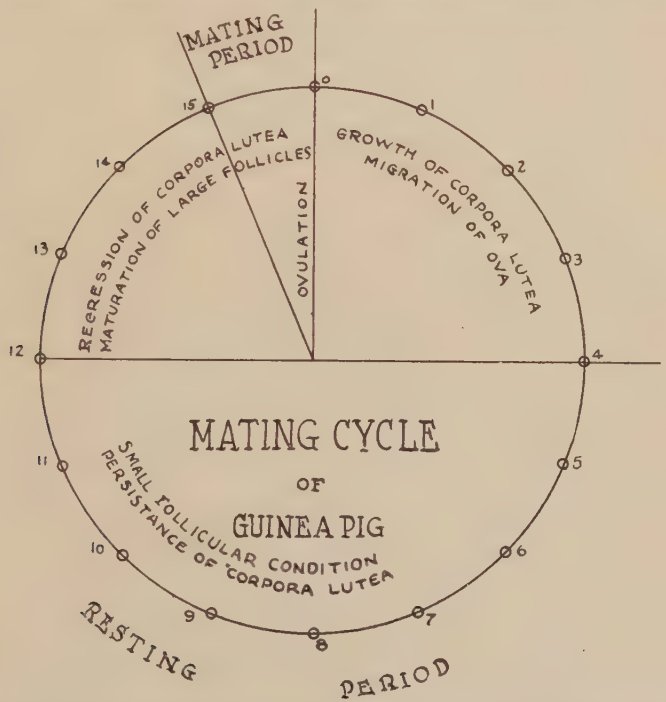


The reproductive system of the mare. c—cervix, f—fimbrae, o—ovaries, t—fallopian tubes, u—uterus.

nature, somewhat like the cow's. The walls are very thick to support the heavy, developing colt. The mare seems better supplied with muscles than most of the other animals and birth usually occupies a much shorter time. Although in many respects similar, the mare and cow differ materially in sexual behavior. The cow will accept the bull but a short time while the mare will stand for three to five days. A mare will usually accept the stud from seven to ten days after foaling and it is a very common practice to mate on the ninth day.

REPRODUCTION IN THE GUINEA PIG

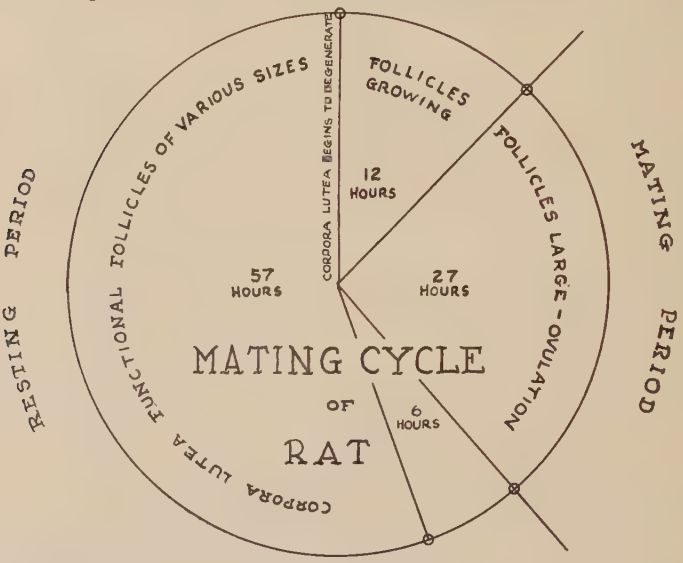
The guinea pig has been a special friend to man. Because of its similarity to us in body, it has been found extremely useful in the laboratories for experimental purposes. Probably more is known about reproduction in this little animal than in any other. The system is essentially the same as the human's, although the cycle is much shorter.



The mating cycle of the guinea pig was the first to have been discovered and the method used by Dr. Papanicalaou has been widely applied to other animals. The cycle shown above will be useful as a guide to all who breed guinea pigs. It will be easily seen that our popular misconception of the prolificacy of the guinea pig, which was enhanced by "Pigs is Pigs," had better be foresaken. The guinea pig is not nearly as prolific as many other animals which have never been so much exalted.

REPRODUCTION IN THE RAT

The rat is another animal which has taught us much of what we know about reproduction. Drs. Long and Evans have studied the cycle of the rat very intensively, and the above diagram is based upon their studies. It will be seen that the period has been divided into hours instead of days.



There is a close parallel between reproduction in the rat and in the rabbit. It is believed however that in the case of the rabbit, copulation is necessary for ovulation, and this is not true with the rat. The cycle of the rabbit also is longer than that of the rat.

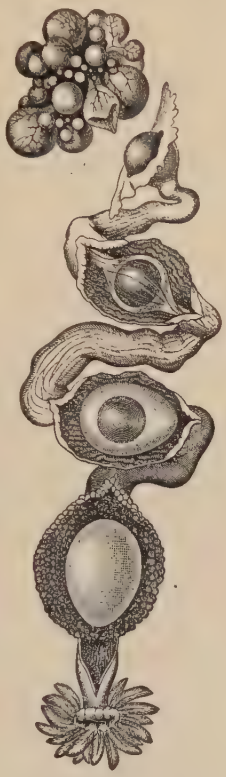
The uterus is double as it is in the bitch or sow and the young are born in litters of varying sizes, generally with about seven to the litter.

REPRODUCTION IN BIRDS

The reproductive system of birds presents a clear illustration of the general principle although there are several points at variance with the mammals, chief of which is the fact that birds deposit the embryo chick in the form of an egg, into the outside world, where it remains in a dormant condition until

it is subjected to certain temperatures when the development of the chick begins. Likewise there is a supply of food within the egg, and this is not provided in mamals, but rather the food is supplied as the embryo grows.

Here is the mechanism of the hen, as an example of the reproductive system in birds. The ovary consists of a great number of follicles loosely united by connective tissue, and within are many of the basic cells which develop into ova. Whereas there is a simultaneous development in mammals, in poultry there is a consecutive development. Each day, or at short intervals of more than a day each, a follicle bursts, and instead of a corpus luteum forming, the ruptured follicle heals, and that is the end. The ovum which is emitted is taken into the end of the fallopian tube, and gradually it moves downward.



Female reproductive system of a fowl.

The part corresponding to the fallopian tubes of the mammal is called the oviduct and is about a foot in length, and the egg is moved along by the wavelike motion of the oviduct. The ovum consists of a large yellow sphere, which is the yolk (the food), and a colorless mass attached to its surface, which contains the germinal material or neucleus. As the ovum descends the oviduct it meets sperm, one of which unites with the nucleus. Several layers are then added to the ovum, including the so-called albumen or white, which is gelatinous in substance. This forms in greater abundance in front of the ovum and thus is deposited in a conical projection. The final layer which is added, is the shell, which serves as a protection, and allows for the evaporation and absorption of water, and other substances. Then the ovum and the material which it has accumulated is laid—what was an ovum is now an egg.

CHAPTER XXII

BIRTH

One of the most wonderful things which nature accomplishes within the bodies of animals is her protection of the mother and the offspring. The young have stayed within their fleshy nest for the appointed time, developing within an envelope. Each foetus is joined to its envelope by a cord which runs from its navel, and which is known as the umbilicle cord. The envelope contains a fluid in which it is entirely immersed, but as it does not need to breathe, it is safer than it would be in a dry condition. This fluid acts as a cushion, preventing injury to the foetus. Beside the fluid within each envelope, surrounding each developing animal, there is additional fluid in the uterus of the mother which affords extra protection. The walls of the uterus are fibrous in nature and greatly enlarged. From the small, dormant uterus it once was, to the enlarged condition, is a very great increase. It must not be thought that this change is caused by stretching alone. It comes about by the process of growth. The first growth started when the mating cycle approached. If the female was mated and the ova were fertilized, the growth continued. If not, it subsided.

After the period of foetal development in the uterus, it is interesting to speculate on the cause of the contraction of the uterus at just the right time. It is also interesting in certain cases to note that births tend to take place at the end of gestation periods of even months or weeks. In the human it is at the end of ten lunar months—280 days; in the cow, ten months; in the mare twelve months. Many birds' eggs seem to hatch in multiples of seven days. The pigeon takes twenty-one days, the hen twenty-one, the duck twenty-eight, and of the small birds many hatch in seven days. Other instances will occur to all of us.

The average actual gestation period of the dog is sixty-one days. Nine days after birth the eyes of the pups will open. It is curious that when the pups are born several days before they are expected they will not open their eyes until about seventy days from the time that fertilization took place. A bitch which I imported arrived from a cold climate into

America during the later part of May. Due to the excessive heat she whelped her pups one week early, but they did not open their eyes until just sixteen days after they were born.

There are three stages in the normal birth. The first is characterized by preparation. During pregnancy the blood and tissues of the body, and especially the reproductive system, become filled with a very large number of little cells called leucocytes, which are the disease germ destroyers. They move about looking for injurious material which should not be in the system. The leucocytes increase greatly in number as the growing foetus becomes ready to be born.

Since there is an opportunity for infection at birth, they are one of the greatest aids to the body. It is interesting to watch the way in which they absorb the foreign matter. They will penetrate even the interior of the large cells and remain there as guards. The normal number of leucocytes in the human being has been estimated to be 8,000 per cubic mullimeter, but just after birth it rises to over 20,000.

When the leucocytes have multiplied so that the system is insured against attacks of disease, a periodic contraction begins in the uterus. The muscles contract and relax at long intervals at first. This usually will send the female searching for a place to make a bed. Sometimes this occurs a day before the birth, and sometimes not until a few hours before. Gradually the pains become more severe and at shorter intervals. Then the mouth of the uterus enlarges due to the pressure which is created from within. Finally the membrane surrounding the foetus ruptures, and the fluid is discharged. The vagina and the mouth of the uterus become relaxed and all of the muscle tension seems to be withdrawn so that they are pliable and soft. Then the second stage begins.

The female will have made her nest or bed and is usually lying on it waiting for the more drastic pains to begin. During this stage the muscles of the abdomen begin to contract in rhythm with the muscles of the uterus. When the pains are in progress the female will strain and, in the case of some animals, usually her muscles will contract so violently that she will stretch straight out and the tension will be noticeable even in her legs which she stretches out as though the contraction took place all over the body. With each of the pains there is a quickening of the pulse and between them the pulse reduces to nearly normal. These cessations in the pains or

muscular contractions give the mother a rest and allow her to store up energy for the next. Each of the contractions moves the young nearer to the vagina until at last it is born.

In some animals like the cow, horse, and sheep it makes considerable difference in what way the offspring is presented, but with the dog, the hog, and others born in litters it sometimes comes head first, and sometimes tail first. With certain animals the presentation is all important. Dr. Stanley Ball, Curator of the Peabody Museum at Yale University and I were interested to learn whether or not the method of presentation made any difference to porcupines. In order to do so we took one of my dogs into porcupine country and when we had treed a pregnant female, we shot her and examined the embryo which was almost ready to be born. There were quills on it about a quarter of an inch in length. So it may be seen that porcupines must be headed in the proper direction, or both mothers and young would die.

Colts and calves break the cord during birth as a rule but in the case of some other animals the mother licks them until she has squeezed the fluid from their hair, and sooner or later, usually very soon, she bites off the cord which runs from the navel of the young and then pulls on it until she has pulled the entire envelope from her uterus, and consumes it. In this way the afterbirth is taken care of.

The afterbirth or placenta is not discharged from some animals for from ten minutes to an hour later and then it is usually consumed by the mother. There is seldom any afterbirth retained in the uterus of an animal having litters as there is from animals having one or two young. Sometimes, however, it does not come away as easily and then it is expelled later. If it were not for this provision, the young higher up in the uterus would have difficulty in being born as there would be an obstruction in the way.

The placenta contains a hormone which is similar in chemical content to that secreted by the follicles. May it not be possible, if indeed not probable, that the animals consume the placenta to obtain this hormone? Certainly some animals eat it which will eat no meat at any other time. It may have some effect upon the proper cleaning after birth, upon the milk supply, upon the subsequent mating cycle.

The mother, in licking her young, generally tends to push it around toward her breast and teats where it first has a meal

of colostrum milk. If you have watched a calf searching for its first meal, you will remember that it instinctively nosed toward the mother's udder. The natural sense of smell, or the irritation of pushing its tender nose against the sharp hairs, probably cause it to move in the right direction, toward the rear of the mother, rather than toward the front. The colostrum is of a different composition than the milk which is secreted later. It is much darker yellow and much thicker. It also contains a laxative which purges the bowels of the accumulated matter which has collected during its development.

The condition of the mother seems to exert a considerable influence on the time which it takes her to give birth to all of her young. Over-fat females usually take much longer than those of normal weight. I have seen a fat bitch have a normal labor with no complications covering a period of twenty-four hours. I have seen a hound which was in running condition accomplish the whole thing in thirty-five minutes after labor began.

After the young have all been born, if there is any foreign matter or retained afterbirth in the uterus, contractions will continue until it has been expelled. Sometimes two young of a litter are born very closely together. This, I believe, is caused by the fact that one is presented from each division of the uterus and they reach the vagina at about the same time. They must continue to move along together, and the second one will be presented before the mother has an opportunity to lick the first one off sufficiently.

The third stage of birth comprises the after pains which tend to shrink the uterus to normal size, and the contraction of the muscles of the vagina and the uterus, and the contraction of the mouth of the uterus to normal size.

When labor begins, some animals make better progress if left alone, but their keeper should be on the lookout for complications or need of human assistance. Carelessness or neglect at this time may undo all that has previously been accomplished through intelligent selection of healthy breeding stock and providing proper care during pregnancy. For this reason it is very necessary to keep a record of the expected date of birth, in order that the breeder may be fully prepared for any emergency.

CHAPTER XXIII

STERILITY

STERILITY IN THE FEMALE

There are instances wherein copulation alone is not productive of results, which may be remedied by artificial insemination. Generally an expert veternarian is required to induce fertility in cases where the mating cycle does not come about naturally. The follicular hormone can be depended upon, and in the future will probably be the main reliance for animals when the luteal bodies do not persist; that is, in those animals which have an intermediate cycle between the regular cycles. With those which are in season to be bred each month or oftener, the follicular hormone is unnecessary. The luteal hormone may be useful, not to produce fertility, but rather to postpone the cycle.

After calving, many cattle do not begin their cycles as soon as they should; others are irregular, and the luteal bodies persist on the ovaries for much longer than nature intended they should. An expert can examine the ovaries through the rectum and easily feel of the luteal bodies, which he can dislodge from the ovaries, whereupon the cow will soon begin a normal cycle. This is being done continually by veterinarians with excellent results. It should not be attempted by the amateur for fear of injury to the ovaries. A hemorrhage of the ovary is easily brought on in this way, and usually results in death.

Sterility cases in mares are not so easily remedied. Frequently it is caused by an acid condition of the whole system, which, when corrected results in normal fertility. Professor W. S. Anderson, to whose works the reader is referred for more detailed study of the question, has done more work on infertility in horses than any other man. He is located at Lexington, Kentucky, in the heart of the blue grass region where he is frequently called to remedy sterility among the great race horses which are bred there. Professor Anderson has told me of interesting cases and how they were treated, and he believes practically all infertility in mares is brought about by poor condition, or from diseases of the ovaries. Sometimes, too, the cervix is too much contracted so there is no opportunity for the sperm to enter.

Massaging the cervix occasionally remedies this, and sometimes artificial insemination is successful.

STERILITY IN THE MALE

Sterility in males is generally caused by poor condition, too frequent mating, diseases of the reproductive organs, failure of the testicles to descend into the scrotum from the abdomen, and by malformations of the reproductive organs.

The sperm of males in poor condition sometimes appear twisted and stunted, or otherwise malformed. Sometimes it proves effective, no doubt obtaining vitality from uniting with the ova, and the consequent nourishment which the newly formed cell draws from the female.

Overweight is one of the most frequent causes of infertility in both male and female. Every horse breeder no doubt has had experience with overfat studs and their failure to reproduce. The remedy lies in more exercise. I know of one stallion which was put into the harness and worked hard. It detracted to some extent from his usual showy appearance, but it made him fertile. Stock farms are seeing the value of working their bulls with oxen in yokes in order to render them more fertile.

One of my purebred hounds showed me the great value of exercise to induce fertility. In the fall when we hunted all night long together, he was in most excellent condition, hard, and sinewy, but when spring came and he had been off duty all winter, he was fat and lazy. I frequently examined his sperm after mating him to my experimental bitches, and the number to be found in each microscopic field was exceedingly variable. I am sure there were more than double the number during the hunting season as there were during the season of inactivity.

Several champion hogs I have observed were willing to breed, but on every occasion they were infertile because of the over fat condition. In fact, this is notoriously a chief cause of infertility among high quality animals.

We should not omit a reference to inbreeding as a cause of infertility. Without doubt it does tend in certain cases to reduce the size of a litter down to a certain point, beyond which it usually increases slightly until it becomes stable. But with animals which produce but one offspring at birth, inbreeding acts as a decided agent of infertility. Perhaps it

should not all be laid at the door of inbreeding, as the basic cause. We must remember that infertility runs in families and that when these families are inbred, we intensify the traits so that extinction frequently follows. The famous Duchess family of shorthorn cattle has become extinct because of this very condition.

Change in climate often renders a female sterile and there are some instances of males apparently losing their power to reproduce when sent from one climate to another. Mares which have been sent from the west to the east are often sterile for several years, which seems impossible to explain.

Last but not least under the causes of infertility we must consider diet. The recent announcement of a reproductive vitamine, gave us an answer to many a vexing question, and vitiated many experiments among laboratory animals, the results of which were laid to some other cause, but which proved to have undoubtedly been due to lack of this vitamine E in the diet.

Some animals live on diets which abound in vitamine E while others obtain but little. Probably it has its greatest significance to dog breeders, for dogs are fed and apparently able to handle, such a wide variety of diets, that they thrive for long periods on poor food. Vitamine E is contained in such foods as: germ oil of whole grains, milks, fruit and many others.

It is of little consequence to human beings who generally obtain a varied diet, but to the animals which are fed on foods that have frequently been robbed of their germs, oil, bran, and other vitamine-containing elements of foods, it may have a considerable effect.

Not only does this vitamine influence fertility but so do all of the others, a deficiency of any one of which may ruin the health of the animal and thus affect the power to produce vigorous sperm or viable ova. There is much to be learned about diet and its effect upon breeding, but suffice it now to do our best to provide *all* of the vitamines, minerals, and a balance of carbohydrates, proteins and fat.

ARTIFICIAL MATING

Artificial fertilization was heralded as being capable of putting breeding on a new basis. In practice it has not come up to the expectations for it. The methods used in horses are

capsule breeding and syringing. The former is done by inserting a thin gelatine capsule into the vagina of a mare that has just been served, and filling the capsule with semen, and then inserting this capsule directly into the cervix of the mare to be bred. The syringe method is similar except that a small syringe is used. There is sufficient semen to serve several mares at each service, and therefore theoretically one service ought to be productive of a number of pregnancies, providing a sufficient number of mares are ready at the same time.

Dr. W. S. Anderson has tried this method and believes that it is impractical as far as horses are concerned. One stallion can usually serve fifty or more mares in a season and under such circumstances there is little need for the breeder to resort to artificial means. I have seen the capsule method used to good effect, but no doubt Professor Anderson's objections are sound.

Very little has been accomplished in the way of artificially mating cattle. As far as swine are concerned, there seems to be small reason to resort to it, and likewise with sheep.

As for dogs, I have found it very successful providing that it is done under proper conditions.

In the case of frequently used stud dogs this method is very useful especially where two bitches arrive to be served at the same time, and both are ready. However, it will be best in making these artificial matings to wait until the third stage of the mating cycle is well advanced.

In the event that any breeder should try forced mating for any reason I want to drop a word of warning learned from bitter experience. One should be extremely careful that the penis does not work into the female's rectum. It very likely will mean death to the female. The lining of the colon is tender, and full of veins. These are the veins which enlarge and cause hemorrhoids, or piles. They may be ruptured, especially if the female is constipated, and she will bleed into the large intestine or colon. Then she will discharge the blood and this process will continue until she bleeds to death. It is difficult for the membrane to heal, because of contamination. This is a common cause of death in mares. Many a mare has died as a result of it, and the horse breeders must use every precaution to avoid it, in the unnatural conditions under which their horses are sometimes mated.

CHAPTER XXIV

SOME PRACTICAL CONSIDERATIONS

TELEGONY

Without doubt the greatest bugaboo in animal breeding is the supposed phenomena of telegony, or the effect of a previous pregnancy carried over to the following. This idea got its inception in the observance by many persons of recessive traits or mutations appearing, which could be laid to nothing which the breeders knew or understood. In the past when new breeds were being originated more frequently than at present, the evidences of supposed telegony were more frequent also.

A new breed is created, as we have seen, by hybridization of two old breeds and then by continuous selection the desired combinations of traits are established. Sometimes, however, new breeds have been originated by taking advantage of recent mutations. Now in either case there are very likely to be many recessive traits which have lingered along in the germ plasm in a veiled condition for many generations, to appear only when they find partners like themselves in the germ plasm of a mate.

This is occurring all the time. Suppose that the female which gave birth to a double recessive of this sort had previously been mated to a male of a different breed, which happened to be of the color of the recessive offspring, would it not be natural to think that the effect of the previous pregnancy had been carried over to the succeeding? Of course it would. Here are two illustrations, one of a human being and the other of a horse:

A mulatto woman gave birth to a child whose father was a low grade white man. Then she married another mulatto and they had a child which was almost white. Both of these people believe that the previous pregnancy affected the second child. We have seen that there is a genetic reason rather than telegony.

In England, Lord Morton had a thoroughbred mare which he bred to a quagga. The foal was born with stripes. The next service the mare was bred to a thoroughbred stallion,

and this colt also had stripes, although they were indistinct. There was much discussion of this occurence and it served to greatly strengthen breeders' belief in telegony. Unfortunately for their opinions many mares give birth to colts which have such stripes when they have not been previously bred to quaggas. We can be thankful that such communication is impossible; the whole lining of the reproductive tract is entirely renewed after each pregnancy, and there is no nerve connection between the young and its mother to account for strange actions of individuals which are so frequently attributed to telegony.

The harm which this deceptive theory has done in the past is not easily calculated. It is immense. Hundreds of thousands of excellent type animals of all sorts have been killed because of their owners' misconception. In fact it has often

The purebred mother of this foxhound was mated to, and raised pups by, dogs of other breeds on two occasions before she was mated to the father of this pup. The previous pregnancies had no effect upon the last.

been proposed to refuse registration to young which have been born to mothers which have ever before been bred to an animal of any other breed than its own, or to a mongrel. Telegony is a myth, and by another generation let us hope that there will be nothing left of the idea but history.

As a matter of fact, young by several different fathers of as many breeds might be carried by a female at the same time without their influencing each other in the least. One of the best pointers of which I know was carried in a litter with mongrels by four fathers, and she has not been affected

in any respect. She is no more related to these half brothers and sisters than would be the chickens which hatch from different kinds of eggs which were set under one hen.

Furthermore it should be understood that the animals which were raised in the same litter are no more closely related than they would be if each had been born from a different litter, providing that they all had the same father and mother. The same thing applies to non-identical twins in human beings; they are no more related than ordinary brothers or sisters.

THE FREE-MARTIN

If a male and female happen to be born from the same pregnancy to animals which ordinarily produce but one offspring per pregnancy, the female is quite likely to be sterile, but the male is not. It is believed that the free-martin is caused by the joining of the placenta of both of the twins, so that the blood of each flows through both, and in the process it is assumed that the testicles of the male secrete a hormone which is carried by the blood to the female, where it acts upon her ovaries thus retarding their development. The explanation seems likely.

Thus when twin calves, of both sexes, are born from separate placenta the female is not likely to be sterile, but where the placenta of both is fused together the chances are great that the female will be sterile. Twin calves, one of each sex, have been born many times and each proved fertile, but also large numbers of calves have been reared carefully in the hope of someday breeding them, only to discover that they never would breed.

HEALTH OF PARENTS AND VITALITY OF OFFSPRING

What has the health of the parents at the time of mating to do with the health and vitality of the young? In general it has no effect. The reason for this is that the germ plasm is isolated, and in cases of illness there is much less sperm manufactured by the male. What sperm he is able to discharge will sometimes be lacking in vigor and appear distorted under the microscope, but judging from results the nucleus is unaffected.

A male that is sick enough to influence the production of sperm is usually too sick to be interested in mating. If sickness of the father could influence the offspring, this would be a sorry world. Millions of children have been conceived when the fathers were in all states of illness. Nature has provided that we cannot influence the germ plasm by ordinary disease.

But the mother provides another angle to the question. In general it may be said that a female animal that is sick enough to have no ripened follicles will not come in season. If she comes in season, she is in pretty fair health. She may be underfleshed, but her condition will not influence the germ plasm. However, after she has once been mated and the young have started to grow, that is another matter. Usually she will nourish the offspring so that they will grow to practically their normal size at the expense of her own body. If there is not enough lime in her food, the young will draw on the lime in her own system.

Her constitution may become weakened and cause a miscarriage in order to build her up and to save her life, or she may dwindle away to a mere bag of bones in order to bring her offspring into the world, and then not be able to nourish them, so that they will perish unless given assistance by the owner.

Before we knew much about nutrition it was the usual expectation of human mothers that they would have to go to the dentist and have many teeth repaired after the birth of a child. The old saying, "A tooth for each child," had its origin in this lack of proper food. It was simply because the developing child was drawing on the lime deposits in the teeth. It can be almost entirely avoided by eating foods which contain calcium.

Fat or overfat females uniformly seem to produce smaller litters than those which are in good condition. The tissue surrounding the ovaries of a fat female is often a great mass of fat, and this seems to act in a most unusual manner, but in a way which might be expected when we consider the reasons.

The accumulation of fat has no doubt been the result of domestication. Under natural conditions it would be expected that no animals would exercise so little that they would become bloated with fat. Indeed, they would have to move to

escape their enemies which would prevent them from becoming as phlegmatic as are many of our domestic animals.

Horses roaming the plains are never as fat as those prepared for market where weight counts for so much in the draft horse. Beef cattle must be shut into small enclosures in order to top them off. Hogs are not given the freedom of large pastures when fattening time comes. Wild dogs are never as fat as many of our domestic ones.

The food which is eaten by an animal is burned up to manufacture energy. This process is called metabolism. Animals which are always thin despite the amount of food they eat, burn up their food rapidly and are said to have a *high* metabolism; those which burn it slowly are said to have a *low* metabolism. The presence of large amounts of fat shows that the animal has a low metabolism or otherwise the fat would have been burned up to form energy, instead of having been stored.

Now this low metabolism also shows that there is a lessened vitality all through the body, and, consequently, the ovaries are similarly affected. On this account only a small number of ova are developed. Apparently fat acts curiously on the metabolism itself. A low metabolism causes fat to accumulate when food is plentiful, but also, the fatter an animal becomes the lower its metabolism becomes also. Hence the way to increase the number of ova developing in a female is to reduce the fat as much as is consistent.

There are animals which lay on a great store of fat which nourishes them through the winter. The raccoon, the bear, the skunk, the woodchuck, and the squirrel are all inordinately fat during the winter. The breeding season of the raccoon comes just after the fat producing season is at its height. In general the raccoon crawls into its den for his long rest about the first of January, in the North. His mating season is usually the last week in January and the first week in February. But fat does not affect the raccoon. He has developed an immunity to it. Instead, the fatter he is, the more chance there is that he will live through the winter. Raccoons conceive regardless of fat, and they are fertile regardless of it. But fertility of other animals will be cut down considerably by an excess of fat because they have not been selected by nature to utilize it as the raccoon has. It is necessary for raccoons to be fat. It is dangerous for the horse or dog for

they must be swift of foot, while the raccoon eats fruit and nuts, and needs no fleetness; he can climb a tree at the approach of danger.

When a female once accumulates a quantity of fat about the ovaries, it takes time to reduce it. The best way is plenty of normal exercise and a light diet. The ideal way is the same as is always preached for human beings—keep thin!—keep the animal in good condition, and avoid the necessity of having to reduce her weight. Fat is accumulated rather slowly, and must be reduced slowly. It is surplus food in storage for a time of need.

Certain breeds are notorious for their easy keeping qualities. Some have longer small intestines than others, as well as lower metabolism. As the food passes through it, the nourishment is absorbed. The longer the small intestine is, therefore, other things being equal, the less food will be required to nourish the animal.

The airedale is an easy keeper and a dog that fattens readily. This may be explained by the fact that they originated in a section of the world where food was scarce and the Scotch were thrifty. Naturally they would have no animals which wasted food, so by the unconscious process of selection they developed a breed that was thrifty like themselves. Most of their creations are of the same sort. The Ayrshire cattle are noted for finding something to eat and thrive where other breeds might not. But the greatest developments in fat production are in the beef cattle and swine. One can scarcely believe that they are related to the cattle and swine from which they have been developed in a relatively short time.

Over-fatness, not being natural, tends to interfere with fertility and must be everlastingly guarded against by the breeder.

AGE FOR FIRST MATING

The question of mating during the first season should be considered in the light of its probable effects on the mother. To my knowledge there have never been any experiments made to demonstrate the effects. Many experts think that the female will gain her full growth providing she is strong and well developed, by the first mating cycle, others deny it. Certainly nature meant that the female should mate in her wild state as soon as she was able or else she would not come in season so early in life. It is definitely known, however,

that when poor, undernourished, or stunted heifers come in season and are bred, that they frequently do not achieve the size that their sisters have attained.

This is a question for the individual to decide by his own reasoning. If the female is large enough, there will probably be no harm done. If she is undersized, it may injure her. But if offspring are very much desired from a female, it is a certainty that if she raises them that they will be just as good as if they were from the same mother when she was much older.

EMBRYONIC DEATH

Very few persons realize the number of young that die in embryo. This is seldom noticed because they are frequently very small when they are born, and have been partially absorbed. Animals usually consume all of the afterbirth, and with it the embryos which have stopped developing at certain stages. It is interesting to note that there often are several of these in a litter. I have examined the ovaries of many bitches which had been extracted by spaying. I have noticed that they frequently had large numbers of luteal bodies. One bitch which had given birth regularly to six or seven pups had twelve luteal bodies on the two ovaries. Another which had never produced over seven pups had ten. The average was nine to ten. So I realized that a large proportion of the pups which are started on their journey through life never so much as see the light of day. Nature is everlastingly selecting, selecting.

She starts her selection with the sperm and ova and continues until the death of the individuals. She kills some which will be too weak to survive when the fertilized ovum is but an hour old. She eliminates others at all stages up until the last day. Young are sometimes born dead. Others are three-quarters formed. Some are mere walnuts in size.

Children, too, are born with their days numbered in a sense. We can make the most of our days by bilogic living and live to our limits, but we can not go much beyond our expected age. There are families, the individuals of which never live to be over sixty. There are other families which boast many members over ninety, and some over one hundred.

No doubt this same thing applies to our animals. I believe that some breeds of animals uniformly live to be older than

others under equal conditions. Dogs have lived twenty-five years on certain diets, although the average natural age is twelve.

It would be of great interest if all the old age deaths of animals were recorded with the registry associations. It would be of considerable value to learn the average natural duration of life of the different breeds. If a line could be developed by selection, for age, which would be longer lived than the usual run, that strain would be of great value. In fact, selection for long life in domestic animals has been almost wholly neglected.

CHAPTER XXV

IN CONCLUSION

When one enters a new field of writing and is fortunate enough to find that what he writes is read by a large number of people, one may expect many questions to be asked. When I began to write for popular breeders magazines, translating the discoveries of the laboratories into, I hope, understandable English, I was entering a new field. Since the subject of genetics had been considered too deep for the layman, no scientist had bothered to question the statement by breaking precedent and writing on the subject for popular consumption. In college I had had a good education on all of the lines allied to breeding, or underlying it, but after some years of disuse of this wisdom, like most college students, I had forgotten all I knew. When it became necessary to return to my books for certain information, there were those long meaningless words again. They took me back to the days when the professors labored with us to make us understand them. With due respect, I realize now that those good men were so much engrossed in the science that they felt others must know the meaning of the words which they used, at least it seemed that such was the case. As a result much of importance went in one of my ears and out of the other.

So when I went back to those books, I had practically to reeducate myself, and I did so by learning the subject in the language which I understood. That is why I have tried to write it in that same language for the benefit of the many others who find themselves in my predicament. As you have found, the subject is not one which may be learned by an easy reading. It takes study, and *careful* study. And even then, there will be questions which may not be clear. It is those questions with which we concern ourselves in this, the final chapter of *The Basis of Breeding.*

After each of my articles in magazines, I received letters, asking questions. One article drew over two hundred such. Some of these letters required replies which could not have been well answered within the confines of a letter, and more especially when one has but a limited amount of time to give to answering them. From the many hundreds of letters received, it is quite easy to discover that there are fallacious

ideas about breeding, which exist in the minds of too large a proportion of animal breeders, or in the minds of people in all walks of life, for that matter. These I have tried to correct. In fact there is almost a standard set of questions which were asked. These have been treated very fully. There were about a dozen questions which were asked by over ninety percent of the readers who wrote, but there were questions of all sorts beside these.

Hence, it would seem appropriate to conclude the book with a list of questions which have been asked me, and others of interest, and the references to the pages in the book where the answers will be found. Of course each answer presupposes that the book has been read. These questions will thus serve as a review and information test, as well as a help in specific breeding problems.

Should one consider an animal a single unit or a composite of a vast number of traits? *Page 1.*

Do the laws of heredity in animals apply equally to human beings? *Page 1.*

Is it worth while to unlearn misinformation? *Page 2*

Has a knowledge of the laws of heredity any economic value? *Page 2.*

What is the average length of a generation of the various domestic animals? *Page 3.*

Why do dogs make the best subject for illustrating the laws of heredity to a general group of breeders? *Page 3 - 4.*

In what ways do the scientist and the layman differ? *Page 5.*

What especial qualities distinguish the scentific worker which the layman would do well to cultivate? *Page 5.*

Can a pregnant mother "mark" her child, or her offspring, by what she eats, thinks, or does? *Pages 6 - 7 - 39.*

Can one affect the offspring by exercising the mother, by showing her different colors, etc? *Page 7, Chap. VII, Page 39.*

Why is it unwise to build a theory on a few instances? *Page 7.*

Why is it unwise to expect an individual always to be representative of the breed from which it comes? *Pages 7 - 8.*

What has the devil to do with insanity? *Page 7 - 8.*

Can we help to better the human race? *Page 8.*

Is the origin of all of the domestic animals known? *Page 9.*

How large was the animal from which the horse is believed to have sprung? *Page 10.*

Has evolution stopped? *Pages 11 - 64.*

Why is the pure sire method so efficatious in breed improvement? *Page 11.*

Who, under the present usual breeding system shapes the destinies of the breeds? *Page 11.*

How was docility ingrained in our domestic animals? *Page 12.*

How were the multiform breeds originated? *Pages 12 - 13.*

Are man's breed "improvements," always real improvements? *Page 13.*

What has blood to do with breeding? *Page 14 - 15.*

Does the term "pure blooded" animals really mean anything? *Page 15.*

Why cannot blood be inherited? *Page 16.*

Will a blood transfusion affect children born subsequently? *Page 17.*

Does blood mix to produce offspring? *Page 17.*

How many ancestors did each of us have 34 generations ago? *Page 18.*

Why do the immediate ancestors count more in a pedigree than remote ancestors? *Page 18.*

What is the actual beginning of all animals? *Page 20.*

How large were we and our animals when we were first created? *Page 21.*

How does the embryo get its food? *Page 21.*

Does the mother's blood flow into the foetus? *Page 21.*

How does one cell become two? *Page 23.*

What are the actual carriers of the heritage? *Page 23 - 28.*

In the last analysis why is heredity a matter of chemistry? *Page 24.*

Why does the embryo increase in size more rapidly as it gets older? *Page 25.*

How many blood cells are there in the human body? *Page 25.*

Are there more than one kind of twins? *Page 26.*

Are non-identical twins more closely related than ordinary brothers and sisters? *Page 26.*

Does the human have a tail during its development? *Page 28.*

Why can one sometimes tell the internal condition of an animal judging from the external? *Page 28.*

How many chromosomes are there in the cells of a man, a horse, a rabbit, etc.? *Page 29.*

How do the male and female germ cells differ? *Page 31.*

What determines sex? *Page 33.*

Does mating late in the mating cycle produce more males? more females? *Page 33.*

Can sex be created to order? *Page 34.*

Are equal numbers of males and females born? *Page 35.*

How does the male cell, (sperm) fertilize the female cell (ovum)? *Page 36.*

Does the body effect the germplasm to change its characteristics? *Page 37.*

Why should we not say, "I have some of his blood in my veins?" *Pages 37 - 38.*

Are the offspring more closely related to each other, than they are to their parents? *Page 38.*

Are acquired characters inherited? *Page 39.*

Does the age of parents affect the offspring? *Page 40.*

Are the effects of disuse inherited? *Page 42.*

What would happen to the race of man if acquired characters were inherited? *Page 41.*

What makes cretins? *Page 44 - 45.*

Is cancer inherited?

What effect do alcohol, and other poisons, have on the germplasm, when given in sufficiently large doses? *Page 46.*

Just how does exercise improve a breed? *Page 47.*

Is there any known mechanism for the transference of impressions from mother to foetus? *Page 48.*

Who discovered the theory of alternate inheritance? *Page 49.*

How did he do it? and where? *Pages 49 - 50.*

What happens when animals differing in one character mate? *Page 51.*

What is Mendelism? *Page 49.*

What are all the possible ways in which black and white can combine in guinea pigs? *Page 54.*

How does heredity reduce to arithmetic? *Page 55.*

How is human eye color inherited? *Page 57.*

Why do parents have offspring differing greatly from themselves? *Page 58, 59.*

Can traits be lost completely from the germplasm? *Page 58.*

Are the determiners of the traits affected by having been neighbors of dissimilar traits, while in the germplasm of an ancestor? *Page 62.*

What is the mechanism of evolution? *Pages 64 - 169.*

What is a sport? *Page 64.*

Why should we not use the term sport? *Page 64.*

What are the sudden changes in the germplasm called? *Page 64.*

Do heredity and environment interact or are they independent? *Page 69.*

Is nature cruel or kind? *Page 70.*

Did Darwin believe man evolved from the apes? *Page 73.*

By what means does nature work to change and improve her creatures? *Pages 73 - 74.*

How may one predict results of matings when several traits are considered at a time? *Chapter X.*

What determines skin color in human beings? *Page 78.*

Can two white people produce a black child? *Page 79.*

Is the inheritance of mental traits a simple matter?

Why does the genius so seldom produce geniuses? *Pages 82 - 83.*

Why does a moron prostitute sometimes produce an intelligent well behaved child? *Pages 82 - 83.*

What is the difference between historical genius and potential genius? *Page 84.*

Is the potential genius always recognized by the world? *Page 84.*

Where can I find a list of the known dominant and recessive traits of man and the domestic animals and birds, and corn? *Page 85, Chapter XI*

What keeps a breed the same, or nearly the same generation after generation? *Page 110 - 169.*

How do pure line boundaries assist the breeder, and how do they hinder him? *Page 110 - 168 - 169.*

Where there is wide variation within a breed what is the cause? *Page 111.*

Why is it dangerous to cross breeds with the object of breed improvement in mind? *Page 114.*

How is it that some traits are inherited only from the maternal grandparent, through the mother? *Page 115.*

Why do certain traits appear in the males and remain masked in the females? *Pages 115 - 116.*

Why do certain traits always seem to adhere to each other in inheritance? *Page 117.*

Why do certain mental traits frequently remain associated with physical traits? *Pages 117 - 118.*

Is inbreeding always dangerous? *Page 119, Chapter XIII.*

What is inbreeding? *Page 119.*

What are some famous instances of successful inbreeding? *Pages 120-123.*

Why does inbreeding need to be done intelligently? Why does it require persistency? *Page 121.*

Has human inbreeding ever been successful? *Page 123.*

Have any human families been carefully studied for good and bad traits? *Page 124-125.*

Where may human pedigrees be filed as we file the pedigrees of our animals? *Page 125.*

How may one test a suspicious animal for purity of breeding? *Page 126.*

How may inbreeding be used to eventually improve the stock? *Page 127.*

How many generations of inbreeding are required to make a stock almost pure? *Page 128.*

Does inbreeding create weaknesses? *Page 128.*

Is an ordinary breed actually an inbred breed? *Page 128-129*

Just what is a breed? *Page 129.*

What makes an animal prepotent? *Page 132.*

Is prepotency a useful term for a breeder to understand? Why? *Page 133.*

Is the mongrel usually a better animal than the pure bred? Is he more useful? *Page 134.*

Why do certain races of men possess certain mental and temperamental traits? *Page 136.*

How has cross breeding been useful in the past? *Page 138.*

Are mules always sterile? *Page 139.*

May the zebra displace the Jack as a mate for mares to produce valuable work animals? *Page 141.*

Why are there so few species on a given continent which are fertile with each other? *Page 141.*

Is the hybrid always more vigorous than the parents? *Page 143.*

What should be the principle purpose of a stock show or field trial? *Page 144.*

Why do animal breeders need an ideal ever before them? *Page 145.*

What live stock associations have created ideals toward which to breed? *Page 147*

Have ideals a real economic value? *Page 147.*

Where can one find a good dog standard and score card? *Page 153.*

What were the first dog associations to establish ideals? *Page 155.*

Why is it dangerous to breed dogs with increasingly smaller brain cases? *Page 156.*

How are ideals valuable in human betterment? *Page 158*

Why is the present system of championship awards often inadequate? *Page 159.*

Why not create an advanced registry for animals on the basis of general excellence? *Page 160.*

What is the best proverb to keep in mind for family or breed improvement? *Page 162.*

Was Abraham Lincoln the product of scrub human stock? *Page 162.*

How may a man start to build up the breed he fancies with a small financial outlay? *Page 167.*

Why is it not always wise to rely upon high priced show specimens for breed improvement? *Page 168.*

Have sudden changes in the germplasm, sometimes a great value? *Pages 169 - 170.*

How can one select, from a lot of young animals, the one which will turn out to be the best? *Page 170.*

What makes a giant, a giant, or a dwarf, a dwarf? *Page 170*

What is the explanation of the difference in size, at birth, between the members of a litter of young animals? *Page 172.*

Is there such a thing as a "hip-pig" or "hip-pup?" *Page 172.*

How is the reproductive system of a flower similar to that of an animal or human? *Page 177.*

Where are the sperm manufactured? How? *Page 179.*

Why are the testicles not retained in the abdomen, like the ovaries? *Page 180.*

Is a male animal usually fertile the first service? Why? *Page 181.*

Must a male animal be bred regularly to maintain his fertility? *Page 181.*

How many female cells (ova) might be fertilized if all of the male cells (sperm) discharged at single mating, found partners? *Page 181.*

How much sperm does a normal man produce in a life time? *Page 181.*

Do all animals have seminal vesicles? *Page 184.*

Is it harmful to allow a young male to mate as soon as he is old enough? *Page 185.*

What is the proper frequency for animal mating? *Page 186*

How large are the ovaries? *Page 187.*

What are the changes which occur in the ovaries? *Page 189*

Does the tendency to have twins run in families? *Page 190.*

Do some families of animals inherit the capacity to produce large litters? *Page 190.*

How do the sperm find their way to the ova? *Page 191.*

Is the number of nipples any indication of the size of the litter which may be expected? *Page 192 - 193.*

What is meant by the "mating cycle?" *Page 194.*

Where may I find a table of the comparative features of reproductive phenomena in the various animals and in man? *Page 195.*

Are there any seasons of the year when more bitches are in their mating cycles, than at other times? *Page 196.*

Which animal makes the best illustration of reproductive phenomena? Why? *Page 179.*

Is there definitely a best time during the mating cycle to mate animals? *Page 199.*

What is the mating cycle of the dog? *Page 202.*

How long will sperm live in and out of the female reproductive tract? *Page 203.*

Will it soon be possible to regulate the mating cycles of animals at will? *Page 206.*

What has temperature to do with the control of the mating cycle? *Page 209*

What controls sex behavior? *Page 209.*

Where can I find the most important facts in regard to reproduction and the mating cycle for man and each of the animals for which the mating cycles are known? *Page 210.*

What prevents the infection of the mother at birth? *Page 223.*

What are the stages of birth? *Page 223.*

Why do females consume the placenta? *Page 224.*

Are porcupines born with quills? *Page 224.*

What is the most frequent cause of sterility in animals? *Page 226.*

Does exercise effect fertility? *Page 227.*

What is the effect of a change of climate on fertility? *Page 228.*

Is it possible to mate animals artificially? *Page 228.*

Can the effect of a previous mating hold over to the next? *Page 230.*

Where did this ridiculous idea get its start? *Page 230.*

What might make people believe it was true? *Page 230.*

Why is it that when male and female twins are born together, that the female is so often sterile? *Page 232.*

What has the health of the parents to do with the vitality of the offspring? *Page 232.*

What is back of the saying "a tooth for each child?" *Page 233.*

What has fat to do with fertility? *Pages 233 - 234.*

At what age should a female animal be mated for the first time? *Pages 235 - 236.*

Does longevity have an hereditary basis? *Page 236.*

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